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ABSTRACT

This paper is the result of a feasibility study on the implementation of computer-assisted-instruction (CAI) for the U.S. Army Bands. The study analyzes the state-of-the-art capabilities of CAI with regard to Army requirements. The contract for the study states: "The objective of this task is to explore and analyze alternate approaches to educating Army musicians in the areas of notation, melody, rhythm, and ear-training in an interactive mode and utilizing on-screen graphic displays and synthesized music. This is particularly important for Reserve Component bandspersons who have no training in these areas available. Results of this study may indicate ways to increased efficiency and quality in training active component bands and provide better remedial tools for instructors at the U.S. Army Element, School of Music (USAESOM)." This paper includes a description of the study procedure, a general background on the theory and use of CAI in music training, an analysis of how they meet the needs of the U.S. Army bands in music instruction, and recommendations and cost figures for the implementation of CAI at the USAESOM. (Author)

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Application of Computer-Assisted-Instruction to the Training and Education of US Army Bands officers, Warrant Officers, Bandmasters, and enlisted bandpersons

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10 March 1986

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ABSTRACT

This paper is the result of a feasibility study on the implementation of computer-assisted-instruction (CAI) for the US Army Bands. The study analyzes the state-of-the-art capabilities of computer-assisted-instruction with regard to Army requirements.

The contract for this study states:

> The objective of this task is to explore and analyze alternate approaches to educating Army musicians in the areas of notation, melody, rhythm, and ear-training in an interactive mode and utilizing on-screen graphic displays and synthesized music. This is particularly important for Reserve Component bandspersons who have no training in these areas available. Results of this study may indicate ways to increased efficiency and quality in training active component bands and provide better remedial tools for instructors at the U.S. Army Element, School of Music (USAESOM).

This paper includes a description of the study procedure, a general background on the theory and use of CAI in music training, an analysis of how CAI could be incorporated into the training of Army bandspersons, an evaluation of the available hardware and software in terms of how they meet the needs of the US Army bands in music instruction, and recommendations and cost figures for the implementation of CAI at the USAESOM.

1. BACKGROUND

> The most important single factor influencing learning is what the learner already knows. Ascertain this and teach them accordingly.[1]

1.1 STUDY PROCEDURE

As an assistant professor of solfege at Carnegie Mellon and the co-author of the computer-assisted-instruction music program CAMUS (Computer Assisted Music Units in Solfege), I was selected by the US Army to do a feasibility study on the implementation of Computer-Assisted-Instruction (CAI) in the US Army Element School of Music (USAESOM).

I began my study by meeting with the Contracting Officer's Representative (COR) to discuss the particulars of the research, as established in the contract. We discussed the needs of the US Army Bands' training and we narrowed down the choice of potential hardware and software needed to sustain relevant pedagogical ideology.

TRIPS

School of Music

I went twice to the School of Music of the Army, Navy, and Marine Corps, the US Army Element School of Music (USAESOM), at the Naval Amphibious Base (Little Creek) in Norfolk, VA : once with my computer systems analyst for two days and once alone for three days. There, we observed classes in theory and ear-training at different levels, from entry level to near graduation level.

Most music instruction of Army bandspersons takes place at the (USAESOM). "The School of Music provides training for enlisted personnel of the United States Army, Navy and Marine Corps, in order to prepare them for service with professional military bands."[2] The School of Music is accredited by the Southern Association of Colleges and Schools.

A typical daily schedule for the Basic Course goes as follows:

- 8:15 - 9:00 Concert Band Rehearsal
- 9:10 - 9:55 Music Theory
- 10:05 - 10:50 Dance Band Rehearsal
- 11:00 - 11:45 Individual Practice or Lesson
- 12:45 - 1:30 Ear Training
- 1:40 - 2:25 Combo Instruction
- 2:35 - 3:20 Drill Band
- 3:30 - 4:15 Military and Physical Training

This is an intensive, almost exclusively music filled schedule of activities, which continues for 23 weeks.

The first week, the enrollees are given the Seashore test as an entrance/placement test. The Seashore test is a series of aural stimuli which require a right or wrong response. There are five tests presented in double columns. They are corrected and tabulated one at a time and the scores are entered in each individual's record.

The curriculum of the School of Music follows the textbook *BASIC MUSIC*. This US government publication (ordering #0502-LP-051-2200) is an excellent book and should be a staple in the library of music educators. It is a straight forward, comprehensive textbook in which theory concepts are clearly defined. *BASIC MUSIC* is meant to be a reference theory book. For assignments, the students use an unpublished spiral bound book with sixteen chapters of melodic and rhythmic exercises. Quizzes are given regularly about twice a week and exams are given every three weeks.

Enrollees who experience difficulty with the course are either encouraged to go to the remedial lab or given specific supplementary exercises to be done under supervision at the remedial lab. This monitored lab is open from 8 AM to 2:30 PM

Monday through Friday, from 6 PM to 8 PM Monday, Wednesday, Thursday, and Friday, and from 12 noon to 2 PM on Saturday.

At the USAESOM, I spoke with instructors and administrators about the criteria and the curriculum of the School. (In section 1.3, I discuss how CAI could be an effective part of the curriculum at the school and in the Reserve components' training.)

To obtain first hand information on the CAI music programs at other schools, I travelled to the University of Illinois and to the University of Delaware.

The University of Delaware

The University of Delaware has a very large, sophisticated system of computer based instruction, coordinated by the Office of Computer-Based Instruction. The Music department uses both PLATO, on the mainframe system, and microcomputers. All music majors take two years of ear-training and theory using CAI for drill and practice to supplement class instruction. Non-majors can take a music theory class in music fundamentals or music preparation, both of which utilize some CAI. There is also a course in computer literacy for music students.

The students use a music instruction series, GUIDO, originally developed for the PLATO system by members of the faculty of the Music Education Department at Delaware. GUIDO is now being ported to the IBM. I saw a demonstration of the IBM version of GUIDO using the sound synthesizer board recently developed there by members of the office of CBI. (See section 2.3 for a description of this hardware.) This very exciting development is significant for this study because it greatly improves the sound capabilities of the IBM PC. I also saw an excellent demonstration of the University of Delaware's videodisk system which is used for lessons in music appreciation, music history and performance recordings.

Illinois State University at Normal

The Illinois State University at Normal College of Fine Arts has been working with Computer-based Instruction (CBI) in the arts since 1976. The Office of Arts in Technology (ORAT) oversees all computer research and CBI courseware development within the College of Fine Arts. As part of its research efforts, ORAT has established working relationships with professional and commercial institutions. The Office is a field test center for Micro Music Inc. (MMI). In addition, ORAT has an ongoing industry grant from Temporal Acuity Products (TAP) to develop software in music CBI. (See chapter 3 for reviews of software.) This is the software used exclusively at ISU Normal. (TAP and MMI have merged, hence we are really talking about one company.)

The lab at ISU Normal is equipped with Apple II microcomputers. Since 1981, the computer project has been expanding. There are now 20 Apple II microcomputers in use in the College and a variety of hardware and sound synthesizers. This year, the lab will add a hard disk and local network to tie the Apple II learning stations together. Software will be developed for this system which will allow the student to access the central disk without handling diskettes.

Courseware is used for a variety of music classes in theory, history, education group voice and brass methods. Student usage of the facilities in Fine Arts averages about 70% to 80%, during the 66 hours the lab is open each week. The lab serves about 800 students enrolled in art, music and theater each semester.

Because the software development and acquisition of hardware and software were sponsored by an industrial grant, no cost figures are publicly available.

Illinois State University at Urbana-Champaign

The Illinois State University at Urbana-Champaign is the site of the Computer-based Education Research Laboratory (CERL). The CERL Music Group has produced the

Interactive Music System (IMS), which runs on the PLATO computer system. There are no microcomputers used for CAI at ISU Urbana-Champaign.

Research and development have produced a new PLATO system to replace the outdated and expensive old PLATO. The PLATO system consists of a large mainframe computer and terminals connected to the mainframe through telephones, satellite disk antennas or Community Antenna Television (CATV). All the software is stored in the main PLATO system. The new PLATO can use microcomputers as terminals. The cost of using PLATO consists of the monthly service charge, the cost of the phone line and phone bills, an hourly on-line charge, and modems. (See Exhibits for cost.) The exact cost for the new PLATO will depend on the number of users. The main drawback to using PLATO is that it can only use PLATO software. As Alfred Bork reports that Luehrman said of PLATO and MITRE, "We need a thousand flowers, not just a few."[3]

ADCIS Conference

I also attended the annual ADCIS (Association for the Development of Computer-based Instruction Systems) conference in New Orleans where colleagues from all over the country presented papers on the state of CAI in many fields. ADCIS always has a stimulating conference where one hears experts and inspired thinkers discuss their ideas. There I heard Alfred Bork, the well known educator,give a talk about good computer program design. Joan Hayes talked about large lab managing, and several of my colleagues demontrasted the software they have designed or use at various universities.

LITERATURE SEARCHES

Previous Studies

In an attempt to find proper documentation on previous studies I conducted several ERIC (Educational Resources Information Center) searches. ERIC is sponsored by the National Institute of Education, Washington, DC 20208. ERIC is a computer database of educational materials. It consists of two subfiles:

1. Resources in Education (RIE)

2. Current Index to Journals in Education (CIJE), an index of more than 700 periodicals of interest to all segments of the education profession.

ERIC collects and indexes journal articles, research reports, evaluation studies, curriculum guides, lesson plans and so forth. I was able to find two feasibility studies for implementation of CAI and two Ph.D theses on this topic.

- A Practical Approach to Computer-Based Instructional Support (CBIS), for the Alberta Department of Education, January 1980.

This is an investigation through surveys and questionnaires for CBIS for the Province of Alberta. This study identified three major CBIS applications which would relieve teachers of some of their administrative workloads.

1. Accessibility of student records within the school.

2. Province wide accessibility of learning aid references.

3. Province wide accessibility of test bank.

This study was well conducted and reported, but it is not directly related to our research. Although it was one of the most recent studies available, it was written in 1980, and would be written differently in 1986. It does contain some valid advice on establishing CBI in schools, recommendations and a forward plan. An excellent list of references is included.

- Low Cost Computer Aided Instruction, Computer Managed Instruction (CAI/CMI) Systems: A Feasibility Study, for the Technical Training Division, Lowry Air Force Base, CO 80230, December 1979.

> This study investigated the feasibility of a low cost CAI/CMI system. Air Force instructors and supervisors were surveyed to determine the potential payoffs of various CAI and CMI functions. Results indicated that a wide range of capabilities had potential for . . . technical training. Surveys of selected computers, terminals, communications, and support software identified candidates for the low cost system.[4]

This is a very interesting feasibility study. Here again, because of the date, 1979, and the needs of the Air Force, very large systems were recommended: minicomputers costing one hundred times more than the microcomputers surveyed in our study.

- A study of the Contrast between Computer-Assisted-Instruction and the Traditional Teacher/Learner Method of Instruction in Basic Musicianship, Arthur Clarence Vaughn, Jr., Ph.D dissertation, Oregon State University, 1977.

> The purpose of this investigation was to determine if computer-assisted-instruction increased the student' ability in the area of auditory stimuli discrimination at a rate different from that of the traditional method presently used to reinforce these concepts.

This is an excellent thesis extremely well documented. Unfortunately, the research was conducted more than a decade ago and the findings related to the mainframe system and GUIDO software. Consequently, the results, such as cost-effectiveness, are irrelevant to our research. However, some findings which are relevant are summarized as follows:

The results of the study showed that students had a positive attitude towards computer-assisted-instruction. Students using the computer achieved higher test scores than those not using the computer. Within the limits of the study, it was found that:

1. CAI was a better medium than the traditional classroom for the teaching of ear-training skills found in basic musicianship.
2. A significant growth in achievement was found in all areas of computer instruction: melodic, harmonic, and rhythmic.
3. By using the computer, the student was able to save a considerable amount of time in ear-training skills.
4. Since many students could conceivably complete the ear-training portion of basic musicianship in less time, the expense of conducting the class might be significantly reduced.
5. The attitude of students, in regard to using the computer for the study of music fundamentals, revealed a willingness to experiment with alternative methods of instruction.
6. A more positive attitude on the part of music educators and

> administrators was needed before any large-scale utilization of CAI could be possible.[5]

- CAI in Music:a survey with attendant recommendations, Morgan John Jones, Ph.D. dissertation, Northwestern University, 1975.

> The purpose of this study was to determine the status of CAI in music education within higher education and to identify and address issues, questions and selected problems surrounding CAI with the ultimate purpose of developing recommendations for its future development based on the strengths of opinions of selected experts in the field.

This paper is worth mentioning, in spite of its relatively early date (1975) because of its excellent bibliography.

Although there are a very few other studies available, these are the most recent and are relevant to the type of findings we are looking for.

Articles

For the last decade, computer-assisted-instruction has been a constantly growing field. As faculty in the music departments of many universities faced the potential of the new technology of computer science they started developing software for music education. There are many articles which describe their innovations and experiences with this new technology. Most of these articles discuss the systems being used, how they were designed and what topics in music they cover. There are also some studies which attempt to evaluate the teaching effectiveness of a CAI system, usually by comparing an experimental group using CAI to a control group receiving traditional instruction in the same subject. Most studies rely on data incorporated in the programs, such as pre and post test scores.[6, 7] But the cost or cost efficiency of CAI in music seems to have been neglected in the literature.

FINDINGS ON MUSIC CAI AT THE UNIVERSITY LEVEL

To obtain some current information on the cost of CAI, I inquired into the setups at the music departments of universities where music faculty members are closely involved with CAI. Even those programs with excellent CAI do not have exact records on all the costs of running their programs. Most can provide original purchase figures for hardware and software, but the cost of establishing the lab, its upkeep, and the cost of monitoring the lab are often part of general budgets and therefore difficult to extract. Quite frequently CAI labs are funded by one-time-only start-up grants.

Some schools installed computers in rooms which needed little adaptation to make them useable. Other schools had to renovate a room completely, sometimes extensively. The cost of the machines alone is often only a small part of the cost of a CAI system. (Please see chapter 5 for an estimate of the start-up and operating costs of a CAI lab.) It will be very useful to publish such figures at the USAESOM when a microcomputer lab is installed.

Carnegie Mellon

At Carnegie Mellon, students in solfege class use a series of melodic dictation programs called CAMUS which were developed expressly for the class, as well as some commercial software from MMI, MECC, and CONDUIT. Depending on enrollment, the lab is used by 50 to 100 students per year, representing the number of students enrolled in ear-training and sight-singing.

The cost of installing the computer solfege lab at Carnegie Mellon, was first, a total renovation of the room, including soundproofing, air conditioning, rewiring, installing counters for desktops, and buying furniture. Furniture included one desk for monitor, and five swivel chairs. the total cost of the renovation and installation was approximately $13,000. The hardware cost was $11,460 for four Apple IIs and peripherals.

Carnegie Mellon estimates that 10% of the original price of the microcomputer station will be spent each year for running the CAI program, where students use the lab on a full time basis. In the computer solfege lab, we found that we have very few expenses apart from nominal fees to the work-study students who monitor the lab. Students do not take disks out of the lab and they are taught at the beginning of every semester how to handle hardware and software.

On the subject of general cost, at the ADCIS conference, Joe Hayes described the check out system used at Western Washington State University to minimize loss and damage to the lab equipment. Each student entering the lab surrenders his/her ID card which is put in an envelope with the cards from the equipment the student will use. This system ensures that students can be held responsible for the equipment they use.[8]

University of Kentucky

At the University of Kentucky, there are five microcomputers in the listening center which are used for CAI.

University of Georgia

At the University of Georgia, in the introductory courses in methods of music instruction, taught to both music and education students, Apple microcomputers and a variety of commercially available software are used to teach CAI. The course uses the microcomputers in the College of Education computer lab. The rest of the Music Department at the University of Georgia does not use computers for instruction.

University of Nebraska at Omaha

The computer music lab at the University of Nebraska at Omaha is operated in conjunction with the Computing Services there. The lab has Apple II and Macintosh microcomputers . The lab is open 74 hours a week and is used by about 100 students each semester for coursework in theory and composition.

SYSTEMS TESTING AND EVALUATION

Having investigated the use of CAI in various settings and the needs of the USAESOM, I tested and evaluated the hardware and software systems which could be used in a CAI program to meet the needs of the Army Bands. With the help of my computer systems analyst, I tested various configurations of the Apple II, IBM PC, Macintosh and Wyse PC computers. We received documentation for the NBI OaSys but were not able to test the machine ourselves. However, this machine is in another category from microcomputers, has no sound synthesis and no music application.(See exhibit) We also tested a broad range of software packages. (The systems are described in detail in chapters 2 and 3.)

The results of this study were presented in a demonstration at the US Army Element School of Music on 8 March, 1986.

1.2 COMPUTER-ASSISTED-INSTRUCTION THEORY

CONCEPT

The theory of computer-assisted-instruction (CAI) owes much to the concept of programmed instruction.[9] In programmed instruction, material is presented in small amounts of text, called frames. Programmed instruction takes place without the direct supervision of a teacher. There are two methods of programmed instruction: linear and branching.

Linear programmed instruction takes students through a linear progression of frames, allowing the student to set the pace at which he/she advances from frame to frame.

Branching programmed instruction allows different students to take different paths through the material according to their responses to the questions at the end of each frame. An incorrect response directs the student to remedial or clarifying material. A correct response allows the student to move on to new material.

Originally, programmed instruction was delivered by textbooks, workbooks or tapes. The arrival of the computer in schools added new dimensions to programmed instruction.

CAI BENEFITS

Using a computer for instruction can never replace good teachers, but as an adjunct delivery method, it offers a multitude of benefits. Fred Hofstetter, at the University of Delaware, has found that CAI, "makes learning more efficient and improves grades."[10] The most important benefit of CAI arises from the interactive nature of the computer/user interface. Because the student must contribute input to keep the program functioning, he/she must pay attention to the lesson. As a result, the student may learn more than in a large lecture situation.

CAI is more efficient instruction because it is individualized instruction: the student

controls his/her own learning process. The student determines when instruction will take place and also controls his/her pace through the material.

CAI offers immediate feedback. Errors are corrected as they are made. When a student practices alone in the traditional way, many hours may be wasted doing exercises incorrectly. The computer relieves the teacher of the need to present repetitive drills. The computer has an infinite patience which is particularly suited to this task. The computer also helps the teacher keep track of students' progress.

CAI FORMATS

The most common educational strategies used in computer-assisted-instruction are tutorial, drill and practice, problem solving, simulation, and games.

A tutorial presents new material and asks questions designed to clarify or enlighten the material presented.

A drill and practice session asks questions designed to promote mastery of previously acquired knowledge through drill or to perfect skills through practice.

Problem solving allows students to discover new skills or knowledge as they solve a problem, and it allows them to practice the skill of problem solving itself.

Simulation programs allow the students to have experiences which time, safety or cost make infeasible. On a powerful computer, a simulation would allow a student to practice his part of an ensemble piece while the computer plays the other parts.

Games can be used for instruction as well as entertainment.

1.3 HOW CAI CAN HELP THE US ARMY ELEMENT SCHOOL OF MUSIC AND THE RESERVE COMPONENT BANDS

CAI can benefit the USAESOM in many ways. As Harvard president Derek Bok pointed out, one of the computers main benefits in education is that it is "principally designed to save time or eliminate drudgery and routine."[11] They also serve to "correlate, support and reinforce the student's classroom experience."[12]

Within the existing curriculum at the USAESOM, I see two immediate areas in which CAI can be useful. The first area is testing. Testing students is as important as it is boring. Let computers do that work, and teachers have more time for making music. Test design, producing, grading, entering grades into grade books, and producing student grades can best be handled by a machine. The Seashore Test or another entrance test specifically designed by the faculty at the USAESOM should be computerized to save time used in correction and to increase efficiency.

The second area is in the remedial lab. In his book, *Learning with Computers*, Alfred Bork writes, "An important elaboration of drill and practice is the provision of remediation tailored to learner difficulties. The choice of the term remediation lies in the meaning of the root term, 'remedy', something that corrects or removes an evil of any kind, and in spite of the condescending connotation that the adjective 'remedial' has acquired."[3] Right now, one instructor must help several musicians at once, several musicians with several different problems. Since there is only one instructor in the lab at any given time, and since ear-training is by nature a one-to-one relationship, it is obvious that the computer has a perfect role as a surrogate teacher. The lab, equipped with microcomputers and a library of appropriate software will make great strides in improving musical skills. Improvement will, in turn, be immediately reflected in performance. A better reader plays better. More music can be learned in a fraction of the time. This "fraction of time" can be measured in the

level of understanding of rhythm, understanding of notation, but most of all, how the musician hears. Aural perception is of momentous importance to instrumentalists. Furthermore, when musicians must teach or conduct a rehearsal, the ear is their most important attribute. Being able to catch wrong notes, identify where they come from, and give direction as to what should be played, separates the professional musician from the incompetent musician.

Apart from the USAESOM, this study addresses the needs of the Reserve components of the Army Bands. The reservists must perform as well as other army musicians. However, the Reservists have a special problem: the gaps created by the typical reserve soldiers schedule, who gets training only two days at a time every two weeks or almost none at all, except "on-the-job" training. Yet, the Reserve bandspersons are expected to be able to perform the same tasks as those bandspersons on active duty.

It is necessary to find ways to provide reinforcement of skills for this segment of Army Band personel. In addition to CAI, the reserve components need Computer-Based-Instruction (CBI). CBI is designed to teach segments of the curriculum and not just reinforce classroom learning. CBI must first present the information to be learned, then drill, practice and test on it, and most importantly, determine what further action the learner needs to take to master the material. Because of its format, presenting information, drilling, and testing, CBI requires more memory than CAI. For this reason, when most programs of music instruction came onto the market, a few years ago, designers for microcomputers avoided CBI because machines didn't have the memory capacity for it. There is a clear need for CBI for Reservists. By making computer-based instruction available to Reservists, their training can be brought closer to the level of that offered at the USAESOM.

In chapter 6, we give our recommendations for implementing CAI to meet these needs for the USAESOM and the Reserve Component Bands.

2. HARDWARE REVIEWS

> We are drowning in information, but starved for knowledge.[13]

The Contract for this study requires the assessment of the following microcomputer systems:

- IBM PC
- Wyse
- Apple II
- Macintosh
- NBI OaSys

The hardware used to implement CAI at the USAESOM should be chosen on the basis of whether or not it can adequately deliver the software that will be used. In this section, we will evaluate those aspects of the hardware which affect its performance in computer assisted music instruction: memory size, graphics capabilities, speed, and sound.

The memory size should be large enough to run sophisticated programs. When microcomputers first came out, their memory did not exceed 64K. Much software was developed to fit this rigorous specification. Fortunately, on most current machines there is sufficient memory. The graphics must be able to display the musical notation as well as the text required in a clear, easily readable fashion. The speed should be fast enough so that the operating system manipulates files quickly, the computer responds quickly to the user during interactive parts of the program, and the user does not become impatient while graphics are drawn. The sound quality should be appropriate for professional musicians. Ideally, a certain amount of manipulation of the waveform should be programmable.

2.1 THE APPLE II

The Apple II series computers are manufactured by Apple Computers, Inc., Cupertino, CA. The series consists of the Apple II, the Apple IIc, the Apple IIe, and the Apple II+. We will consider only the Apple IIc and the IIe because the II and the II+ are no longer in production. Apple II software runs on all Apple II models.

MEMORY SIZE

The Apple IIc is equipped with 128K of memory. The Apple IIe is equipped with 64K. An additional memory expansion board can be purchased for the IIe which adds another 64K of memory. However, and this is very important, the memory is organized in two pages of 64K each; only one page can be used at a time. While a program is running on the first page, it cannot use any of the information stored on the second page. Thus you can only *run* programs on 64K of memory, but you can store information on 128K.

The memory available to run programs on the Apple II is further reduced by the needs of the operating and programming systems.

- The operating system for Pascal or BASIC uses 16K.
- The graphics capability uses 8K.
- The operating system (Input/Output, the system stack, input buffers and the like) uses 2K.
- The disk operating system uses 10K.

This adds up to 36K, leaving only 28K of memory for the programs themselves.

The memory size needed to run a music education program varies according to the complexity of the program. In section 3.1, we define good music education software.

DISK CAPACITY

The Apple II series computers all use 5 1/4 inch SSSD (Single-Sided Single Density) floppy disks. Each floppy disk can hold 140 kilobytes (143,360 bytes) of information.

GRAPHICS

The Apple II series computers have built-in graphics capability. Computer graphics are displayed in monochrome (black and white or black and green) or in color. The clarity of the picture depends on the resolution.

The Apple II monochrome graphics use green on a black screen. The monochrome resolution is 280 by 192 pixels.

The Apple color graphics use blue, green, orange, purple and white on a black screen. The color resolution is 140 by 192 pixels. These specifications have allowed the Apple to be used successfully for a large number of music programs.

SPEED

There are three speeds which affect the performance of music education software: clock speed, disk speed and graphics speed.

The *clock speed* indicates how fast the microprocessor can execute instructions. The Apple clock ticks at 1.023 million cycles per second. (The microprocessor reads one byte per cycle.) Other, more current machines, such as the IBM PC or the Apple Macintosh, are four or more times faster than the Apple. While the Apple's clock speed is adequate, a faster speed takes less time to draw notes, to respond to user input, or to calculate grades.

The *disk speed* regulates how quickly the machine accesses disks. Disk speeds are often compared by measuring the time it takes to load a file. The Apple loaded the file CAMUS in fifteen seconds, which is relatively slow. It took twenty seconds to boot the file, which is also slow. Disk speed is a concern in a program which repeatedly accesses disks, such as one that keeps track of student progress. It is not a concern in a program which accesses a disk only once, when the file is loaded.

The *graphics speed* depends on the language and the hardware which is used in the program. The Apple has a relatively slow graphics speed, which means that

relatively much time is spent waiting for the computer to draw notes or write instructions.

Speed is important in computer assisted instruction, because the computer should be as responsive as a teacher would be. The faster the computer answers questions, corrects errors and writes notes, the more likely the program is to maintain the student's attention and the more efficient use it makes of the student's time. The Apple is not as fast in these three areas as some of its competitors.

SOUND

The Apple II computers have an internal speaker which produces the harsh sound of square waves. The speaker can be programmed with a routine to click at a specified frequency which produces a corresponding pitch. (Such as A=440.) This routine approximates the pitches of a musical scale. However, the pitch loses some accuracy in the higher ranges. Consequently, the quality of the sound and the accuracy of the pitch both leave something to be desired. Our experience with the sound capabilities of the built-in speaker of the Apple has shown that it is not totally satisfactory for professional music programs.

Synthesizer Boards For The Apple II

The Apple II can be used easily with external synthesizer boards. A synthesizer board is a device which translates computer instructions into musical sound. It can be played through an amplifier or through headsets. The sound quality of the synthesizer board is much more appropriate for professional music making than that of the Apple speaker. It also allows students to use headphones, which insulate them from other distractions, especially in a music laboratory with many work stations.

There are many synthesizer boards on the market for the Apple II because the architecture of the slot in the Apple II into which they fit is simple and well described in the documentation provided by Apple.

Mountain Music Board

The Mountain Music Board is the synthesizer board with the best sound quality available. It is available from Mountain Music, Inc. at a cost of $395. It has sixteen voice capability; each voice is separately programmable with instrument definitions and music dynamics. Sounds can be defined using additive synthesis of sine waves. Multiple waves can be combined within a voice to produce a wide variety of partials. The Mountain Music Board has a useable pitch range of 96 half steps from 30 to 8300 Hz with a maximum output of 13000 Hz. (A piano keyboard has a pitch range from 27.5 Hz A-0 to 4186 Hz C-8.) The Mountain Music Company provides extensive documentation of its hardware. As a result of this documentation, custom software can be written to adapt the Mountain Music Board to any music program.

MMI DAC Board

The Micro Music, Inc. Digital to Analog Converter (DAC) synthesizer board has a list price of $160. It has four voices and comes with a built-in amplifier. The voices are user programmable and are defined by additive synthesis of sine waves. It is possible to store 8 user definitions in memory at a time. The useable pitch range of the MMI DAC Board is 96 half steps from 65 Hz to 1046 Hz, with a maximum output of 6000 Hz. The pitch is defined in quarter tones.

Passport Soundchaser Music System

The Soundchaser Music System is a digital music sound system which uses the Soundchaser MX-5 synthesizer board. The system includes the synthesizer card, keyboard, connecting cable, drum sync cable, and a program package for $1495. It is available from Passport Designs, Inc. or from Wenger Corp. The soundchaser has 8 voices. It offers both square waves and sine waves. Voices are defined by filtering (subtractive synthesis) the waves. The user also has a variety of options for defining the envelopes. The useable pitch range of the Soundchaser is halfsteps from 30 Hz to 8300 Hz, with a maximum output of 20000 Hz, but only four octaves are available at a time.

Alf Music Board

The Alf Music Board is available from Alf Products, Inc. in two models. The Alf MC-1 has nine voices, costs $75 and is recommended by the manufacturer for hobbyists. The Alf MC-16 has three voices and costs $130. It is recommended for professional musicians because of its extended range, volume controls and more accurate pitches. It is possible to connect several Alf boards in succession to obtain more voices. These boards require an external amplifier. The Alf uses square waves. It has a useable pitch range from 30 Hz to 8000 Hz in quarter tones.

Survey of Synthesizer Board Usage

The latest edition of "Music Programs for the Apple" (1984), a catalog of publicly available music software for the Apple, (See Appendix II, Resources.) lists 162 titles. Of these 162 titles, 59 are clearly inappropriate for our research for a variety of reasons. They are based on theory books quite different from *Basic Music*, the textbook used at the USAESOM, or the approach they use is juvenile. Some of these programs are not theory and ear-training programs. They are record keeping programs intended for school records and high school marching band inventories, or they deal with set analysis and composition.

The remaining programs will be categorized according to their sound synthesizers. These programs demonstrate the diversity of software written for different sound boards. It is to be emphasized that this list is intended to give a quantitative, not qualitative, overview of the sound synthesizer boards used with the Apple II.

- 34 of the programs require no synthesizer board.
- 29 of the programs require a Micro Music DAC Board.
- 14 of the programs require the Soundchaser System.
- 13 of the programs require an Alf Board.
- 9 of the programs require the Mountain Music Board.
- 4 of the programs require other synthesizer boards.

PRINTERS FOR THE APPLE II

There are two distinct types of printers which will work with the Apple II, dot-matrix printers and formed character (or daisywheel) printers. Dot-matrix printers produce letters from a series of dots. The letters produced are similar to the characters on a computer screen. Dot-Matrix printers are used to print graphics and text. Daisywheel printers are like typewriters, they have a wheel containing characters which strikes a ribbon to produce the printout. Daisywheel printers cannot print graphics.

Although the letter quality of a dot matrix printer is not as high as that of a daisywheel printer, for the purpose of CAI at the USAESOM, we recommend dot-matrix printers because of their versatility. There are a variety of printers available for the Apple II. Software that prints screens of information cannot possibly be made compatible with all the printers. The Apple Imagewriter II is a dot-matrix printer which meets the USAESOM's requirements for music and text printing with CAI programs. However, there are very few Apple II programs that support printers.

CONCLUSION

When the Apple II came out in 1978, it was one of the best in the field. A large number of music education programs have been written for the Apple. Their authors capitalized on its good graphics and user friendly appeal. However, at this time, most of the newer, faster, more sophisticated machines with larger memories have the ability to perform better in computer-assisted music instruction.

2.2 APPLE MACINTOSH

The Macintosh is manufactured by the Apple Company. The original Macintosh was configured with 128K. It has been replaced by the "Fat Mac" which has 512K and the "Big Mac", which has 1,024K of memory. The Macintoshes use a 3 1/4 inch Macro floppy disk with a hard cover which is less easily damaged than ordinary 5 1/4 inch floppies. The 3 1/4 disks hold 400K for a single sided disk (used for the Mac and the Fat Mac) or 800K for a double sided disk (used for the Big Mac). The Macintosh comes with one disk drive; a second drive either hard or soft can be added.

OPERATING SYSTEM

The Macintosh has an innovative operating system which aims to make communication between the user and the machine as simple and direct as possible. It is based on the "mouse", a handheld device used to control the cursor and "icons", which represent various system functions. Unfortunately, the mouse is susceptible to damage because of the very features that make it easy to use. It is small, very mobile and attached to the Macintosh by a thin cable. The options available at each stage of a program or the operating system are presented in a menu of icons. Through the mouse, the user maneuvers the cursor to the icon which represents the function he/she wants carried out. When the function is selected, a pull down menu appears showing the next level of operations. This is an ingenious architecture, but it is difficult to program. This may explain why so little CAI software has been written for the Macintosh.

GRAPHICS

The Macintosh has very high quality built-in graphics capability. It offers only black and white monochrome. The monochrome resolution is 512 pixels by 342 pixels.

SPEED

The clock speed of the Macintosh is approximately 7 megaherz. (7 million cycles per second.)

SOUND

The Macintosh has good built-in sound capability, better than either the IBM PC or the Apple II. It has four voices and digital waveforms which allow the user to draw any waveform he desired over a nine octave range. The built-in sound of the Macintosh is better than the sound of some synthesizer boards, such as the MMI DAC board, but not as good as the Mountain Music Board.

PRINTERS FOR THE MACINTOSH

There is only one dot-matrix printer which works with the Macintosh, the Apple Imagewriter. There is a laser printer for the Macintosh, which provides excellent quality printing, but not all programs will run with a laser printer and the cost of a laser printer is about four times that of an Imagewriter.

CONCLUSION

The Apple MacIntosh is a technically superior machine to the Apple II and the IBM PC for musical purposes. Unfortunately, so far NO music education software is commercially available for this machine, although there are a number of music transcription programs for the MacIntosh.(See Software reviews chapter) There will probably be some programs of ear-training/theory starting to come out in the next year.

2.3 IBM PC

The IBM PC is manufactured by IBM. It is available in three models, the PC, the PC XT and the PC AT. The PC XT and the PC are the same model; the PC XT uses a hard disk drive and a floppy disk drive, while the PC uses two floppy disk drives. The PC AT is a faster, somewhat improved, and hence more expensive version of the PC.

MEMORY SIZE

The IBM PC can be configured with different amounts of memory. The flexibility of the memory is one of the IBM PC's great advantages. The minimum configuration is 64K and the maximum is 640K. Normally, PCs are configured with 256K when purchased. Memory can be added in the form of memory chips. To increase the memory beyond 256K, the user must add a memory expansion board. Memory chips are plugged into the expansion board until the memory reaches 640K. The amount of memory selected depends on the user's particular application. Within the PC's range of memory size, 64K is inadequate and 640K is more than adequate for the available music software which we would recommend to the USAESOM.

DISK CAPACITY

The IBM disk drives can store 360K on a floppy disk. The IBM PC XT model substitutes a 10 megabyte (10,240,000K) hard disk drive for one of the floppy disk drives on the regular PC. The hard or fixed disk cannot be removed like a floppy disk; it is permanently installed in the disk drive. This is useful for a system which keeps track of various users, since the data on the hard disk never leaves the computer.

GRAPHICS

The IBM PC does not have built-in graphics capability. Instead, a circuit board is plugged into a slot inside the computer which enables the PC to display graphics. There are two types of graphics that the IBM PC can display: monochrome and color. Each of these requires its own type of monitor and graphics board. Most music programmers for the IBM PC use the color monitor and graphics board. The

resolution of graphics on the IBM PC with color monitor and board is 320 by 200 pixels for color graphics and 640 by 200 pixels for black and white. There are sixteen colors available on the color board. The resolution of the IBM PC with monochrome monitor and board is 720 by 328.

The industry standard IBM PC graphics boards are made by Hercules Computer Technology. Software companies design their software to be compatible with the Hercules boards. Most other graphics boards for the IBM PC are advertised as being "Hercules compatible."

SPEED

The clock speed of the IBM PC is approximately 4 megaherz (4 million cycles per second). This is four times as fast as the Apple II series.

The disk speed of the IBM PC is also faster than the disk speed of the Apple. (As an example, the PC loaded the CAMUS file in 8 seconds, and booted it in 18 seconds. (Compare these figures with 15 seconds to load the file and 20 seconds to boot the file on the Apple.)

The faster speed of the IBM PC means that in an interactive program less time is spent waiting for the computer to respond.

SOUND

The IBM PC has sound capabilities similar to the Apple II series. It has a built-in speaker which produces the characteristic beep sound of a square wave.

Neither dynamics nor envelope shaping is possible. Because the desired pitch can be specified in megaherz and not in terms of the clock speed, the IBM PC does not suffer from the tuning problems that the Apple exhibits in the higher range. The note duration of the IBM PC is also more accurate than on the Apple.

SYNTHESIZER BOARDS FOR THE IBM PC

Like the Apple, the IBM PC can accept plug-in sound boards that perform sound synthesis. So far, the only board for the IBM PC is being developed at the University of Delaware. The University of Delaware Synthesizer Board for the IBM PC has all the features desirable for use in computer-assisted music instruction. It uses the SID sound chip found in the Commodore 64 computer. When the Commodore 64 first came out in 1981, it received good reviews for its sound capabilities; BYTE magazine said that it was worth buying the Commodore 64 just to get the sound chip.

The University of Delaware synthesizer uses two of these chips to get six voices altogether. Each voice has individually programmable waveform, envelope and frequency, allowing several tone colors to be synthesized at once. The possible waveforms are: triangular wave, sawtooth wave, variable-width square wave and noise. The envelope (or articulation) for each voice is specified by ADSR (attack, delay, sustain, release). The frequency of each voice can be varied from 0 to 4000 Hz, giving the synthesizer a greater range than any conventional musical instrument. Additional features of the Delaware board include the ability to ring modulate two voices to produce clangorous gong-like tones, and the ability to filter the synthesized tones with either lowpass, bandpass, or highpass filters. Filtering is a way of modifying tone color to emphasize or deemphasize different partials of a synthesized waveform. The Delaware Synthesizer is 10 inches long, fits in an IBM or Wyse PC and has a headphone jack. The waveform, envelope and frequency capabilities of the University of Delaware Synthesizer Board make it an excellent choice for use in computer-assisted-music-instruction. Programmers at the University of Delaware are rewriting their GUIDO ear-training programs for the new synthesizer board. It is expected that music educators will also be eager to adapt their programs to use the University of Delaware Synthesizer Board.

PRINTERS FOR THE IBM PC

There are a number of printers available for the IBM PC. We have found that the IBM Proprinter, a dot-matrix printer, performs well in printing both music notation and text.

CONCLUSION

We feel that the IBM PC offers reliable features: good speed, memory, available plug-in sound synthesizer board, and has very good potential for music education software development.

2.4 WYSE

The Wyse is an IBM clone. It is system and data compatible, which means that all peripherals and software which work on the IBM PC should work on the Wyse. It can use the Delaware sound synthesizer board and all the recommended software in chapter 5.

The main difference between the IBM PC and the Wyse is that the Wyse has only two slots in which boards can be added. One slot is needed for the graphics board. The other would be used for either a MIDI interface or a sound synthesizer board for music applications. Unfortunately, this would make it very difficult to use programs which use MIDI, and programs which use a sound board. It takes time and dexterity to install or remove boards from the Wyse, and damage to the boards could result. We could not recommend that it be done frequently. BY comparison, the IBM PC has five slots for these extra boards. However, it is possible to buy an extra expansion chassis for the Wyse which will add four slots (see chapter on costs). So we suggest that this expansion chassis is an abolute necessity if we want to make full use of the computer, for MIDI, for plugging in a printer, and for adding memory in the case that good transcription programs do come on the market in the near future.

2.5 NBI OaSys

The NBI OaSys is a minicomputer system: a small mainframe computer with several work stations connected to it. A component of this system is a microcomputer work station, the OaSys 2000. We did not evaluate the OaSys 2000, because it is a strictly business computer; there is no music software available for the OaSys 2000. We included literature for the OaSys 2000 in the exhibit chapter. The cost of such a system would run about ten times more than the average cost of the other machines we reviewed.

3. SOFTWARE REVIEWS

"The basic guiding principle . . . is that pedagogical issues take precedence over technical details such as the nature of the hardware."[14]

3.1 SOFTWARE EVALUATION CRITERIA

The software for this project must first and foremost meet the educational objectives set forth by the USAESOM. As stated in the STAS contract, these objectives are:

1. Assist in the instruction of students at the USAESOM.
2. Provide computerized music tutorials in notation, rhythm, melody and ear-training.
3. Provide instructors and students with hard-copy results of tutorial exercises and assess student progress.
4. Provide progressively more advanced tutorials for more advanced students.

In addition to meeting these objectives, we also require the software to use a sound educational strategy appropriate to the USAESOM, to have a good student/computer interaction and to be technically sound. These specific criteria are elaborated in the next section. (The delivery strategies used in CAI are described in section 1.2)

CRITERIA FOR CAI PHILOSOPHY

We define good music education software as programs in which the student/computer interaction resembles that of a real teaching situation. This implies that it should be as easy to enter notation into the computer as it is to write notation on paper with a pencil. It implies that good music education software allows the student to use a reasonably full musical language. It implies that this language should follow the conventions of standard musical notation. (i.e. no asterisks or letters for accidentals)

Good music education software allows the student to repeat questions, to change answers, to add and delete according to the interaction provided by the computer.

These functions can be memory gluttons. In designing software, authors find themselves constantly faced with choices to be made between desirable features and manageability of the complexity the features bring to the program. It is preferable to eliminate some lesson content and preserve the quality level of the interface than to have a program with complex exercises which are frustrating for the user because of a lack of tools with which to execute them. This does not mean that complex exercises with good quality interface cannot be programmed, but it does mean that they require expert programming skills and large memory storage. It also means that quality programs must be developed with close cooperation between pedagogical developers and programmers. We agree with Alfred Bork, the noted computer education expert when he says, "Such simple minded tactics as multiple choice should be avoided."[14]

Interaction:

The interactive nature of computer instruction is its greatest attribute. Good instructional software takes advantage of interaction. Interaction is what separates good instructional software from glorified textbooks. However, Vaughn states "As age increases, the world is viewed in more general and abstract terms and less in tangible and time bound contexts. So there is an increase in the ability to comprehend and manipulate abstract symbols and relationships without the benefit of direct and tangible experience."[5] Sometimes, "interaction" in programs becomes endlessly redundant exclamations of encouragement.

Musicality:

In a music instruction program, randomly generated examples often do not make sense; they will not be "musical".[15] It is possible to program the computer with rules of composition which allow it to create more musical examples, but that is a very complex task that uses a great deal of memory. Consequently, for time and budget constraints, most programs randomly generate musical examples. It is wise to beware when choosing such programs.

Sequence:

The sequence of instruction must be clear, logical, and easy to follow. Often we see programs in which the sequence of events is complicated and difficult to follow.

Levels of Difficulty:

There must be different levels of difficulty available. As the student masters one level, he should be able to move up to a more challenging level.

Novice User:

The program must be able to be used by those with no previous computer experience.

Instructions to User:

The instructions, both on-line and in the documentation, must be clear and complete. They should explain the objective of the lesson. They should explain how the program works, how the student is to enter his responses, how to access "help", and how to quit the lesson.

Help:

The student should be able to access the "help" screen at anytime for further instructions or clarification, especially during the exercises, when help is most often needed.

Errors:

The computer should be able to differentiate between unacceptable input and an incorrect response. Unacceptable input (for example, responding "M" as the name of a note) should be either disregarded (not even printed on the screen) or answered by repeating the the acceptable parameters of response. ("M is not a note name. Please enter a note name between A and G.") The system should not crash when faced with unacceptable input.

Content Errors:

The content must be factually correct. A program containing misinformation or which grades responses incorrectly is unacceptable.

Documentation:

The accompanying documentation should clearly describe the technical details needed to interface the computer with synthesizers and any other peripheral equipment.

Authoring System:

When appropriate, the program should be designed with an authoring system which allows the instructor to add and delete examples and drill items.

In making choices for software reviews, we attempted to identify programs relevant to the needs of the USAESOM. Even though we were lent quite a number of software packages, we did not receive for review every piece of software for every synthesizer and every microcomputer on the market. This is in no way the result of any intentional oversight.

3.2 SOFTWARE FOR THE APPLE II

ARNOLD, Micro Music, Inc. (MMI), $150. This program requires the MMI DAC board. ($160, discounts given for bulk orders.)

ARNOLD is designed to teach tone recognition and melodic memory skills. It features ninety-five melodic dictations on five different levels. Each dictation begins with the major scale in which it is written. Then the first two notes of the melody are played and the user is given the chance to enter them. Each time, two more notes of the melody are played and the user enters the melody so far. The user inputs using the arrows and the space bar.

AURAL SKILLS TRAINER, Electronic Courseware Systems (ECS), set $99.95, each lesson, $39.95. Aural Skills Trainer consists of three lessons: INTERVALS, BASIC CHORDS, and SEVENTH CHORDS.

AURAL SKILLS TRAINER: INTERVALS is designed to improve music students' ability to perceive and identify intervals. The computer plays an interval and the student identifies it.

The interval is sounded only once and cannot be repeated. To enter the name of an interval, the student uses the top row of keys on the computer keyboard. The number of the interval does not correspond to the number of the key. The correspondence is: m2:1 M2:2 m3:3 M3:4 P4:5 TT:6 P5:7 m6:8 M6:9 m7:0 M7:- P8:=. This system creates unnecessary confusion. The system crashes and reboots if any key other than an acceptable response key is typed. There is only one level of difficulty. However, a nice feature of this program is that the student's progress record can be printed.

AURAL SKILLS TRAINER: BASIC CHORDS is designed to improve music students' ability to perceive and identify major, minor, augmented and diminished chords. Since

the program uses the Apple internal speaker, which has only monaural sound, it presents the chords in arpeggiated form.

This drawback can be considered a positive factor if the user is new to chord recognition, since it is easier to hear chords in arpeggiated form. The chord is only played once and only one chance is given for a response. A nice feature of this program is that the student's progress record can be printed.

AURAL SKILLS TRAINER: SEVENTH CHORDS is designed to improve music students' ability to perceive and identify seventh chords. This is an ear-training drill similar to BASIC CHORDS. The arpeggiated seventh chord is played and the student is given the choices: major, minor, augmented or diminished. A nice feature of this program is that the student's progress record can be printed.

CATCH THE KEY, MMI, $50. This program requires the MMI DAC Board ($160).

CATCH THE KEY is designed to provide drill and practice in the recognition of key signatures in treble, bass, alto and tenor clefs as well as on the grand staff. The drills are run either timed (game mode) or untimed (tutor mode). The computer presents randomly generated key signatures in the clef chosen by the user, who enters his/her response by typing the letter name of the key, and "F" for flat and "S" for sharp. When the key signature is displayed, the computer plays the tonic chord, so that the user can identify it as Major or minor. **CAMUS--MELODIC DICTATIONS**, Conduit. Each disk, $50. Set of four disks, $150. Mountain Music Board optional.

(The following description was provided by the author.)

CAMUS, Computer-Assisted Music Units in Solfege, is a series of 400 exercises for the development of musical skills. Melodic Dictations (a subset of CAMUS) is a set of computer materials to help train the ear to perceive musical sounds in relation to musical notation. The dictations included in the materials address a wide variety of

listening problems, such as how to recognize particular intervals, rhythmic intricacies, and mode colors. The primary aim of the dictations, however, is to help student improve their sense of pitch.

The materials are based on the musical discipline of Solfege, which teaches three skills: reading, hearing, and writing. The practice of musical dictation helps students to learn to write music, a skill which requires a synthesis of the reading and hearing skills.

Melodic Dictations contains four disks covering several different levels of difficulty. Each disk contains ten groups of ten dictations. The dictations were created by the author, rather than machine generated, to ensure musically pleasing melodies. Disk #1 dictations are easy enough for high school or university level music students with little experience in ear-training. The melodies in these dictations are made up of simple rhythms, include from seven to twelve notes, and cover all major and most minor keys. Disks #2 and #3 introduce more complex rhythmic notation, chromaticism, and modulations. In general, these disks parallel four semesters of ear-training. Disk #4 dictations contain melodies up to eighteen notes long, mostly atonal, and are difficult enough to challenge most advanced music students.

The program is very easy to use. Students can hear the dictation and their own rendition as much as needed to complete the drill. The editor is complete and all commands are on screen at all times. When graded, both versions appear on screen with the grading of pitch and rhythm. **CAMUS--SIGHTREADING IN ALL CLEFS**, Under consideration by Conduit, suggested retail price: $50 .

(The following description was provided by the author.)

CAMUS--Sightreading is the second set in the CAMUS series. It is designed to teach sightreading in all clefs. User may pick one clef to be learned/or practice or a combination of as many clefs as desired. The exercises begin by introducing notes which are points of references, such as C and G. It then proceeds to add notes an interval of a 2nd up or down from these original points of reference, then a 3rd, then a 4th and finally all the notes of the staff. The idea is that it is important to learn reading notes in relationship to each other.

CLEF NOTES, ECS, $39.95.

CLEF NOTES is designed to improve the speed with which a student can identify music notes as they are placed on the staff, using Treble, Alto, Tenor and Bass Clefs. The program draws a note on the staff in any of the four clefs and the student types in the name of the note, using a movable cursor. The computer marks the answer right or wrong, clears the screen and proceeds to the next example. This program would have a certain limited use for a person who is a beginner at reading notes, but it is not appropriate for the professionally oriented musician.

The main drawback to this program is that it uses randomly generated notes shown one at a time on the staff. This is not an efficient way to learn to read notes. There is only one level of difficulty. At the end of the exercise, the student's score is given in percentages.

DIATONIC CHORDS, MMI.

Western Michigan UNiversity Diatonic Chords is a tutorial program designed to improve skills in taking harmonic dictation. After choosing one of six chord categories, you can hear the key established and start writing first the bass, then the soprano, and finally the Roman numerals and the inversion. There are six levels of chord categories, ranging from Primary Triads to Dominant Sevenths in all inversions. The program allows students to repeat, delete before entering, and hear the key at any time during the drill. The program will play back an error and compare it with the correct answer. This is a very good program, very useful, but not directed to the needs of the USAESOM as described in the contract.

DOREMI, MMI, $75. This program requires a MMI DAC Board ($160).

This program is designed to be an introduction to ear-training using the solfege syllables. It is a good but extremely simple program, not really suited the needs of the USAESOM.

ELEMENTS OF MUSIC, ECS. Each disk: $39.95. Set of three: $99.95. ELEMENTS OF MUSIC is an entry level musical notation program. This series consists of three exercises: Pitch Identification, Key Signatures, and Keyboard Recognition.

The program offers both drill and testing modes. The testing mode can be used with or without a time limit on the response period. Each exercise includes progress tests, progress reports available to the user and an instructor's file for access to all students' records. This set of utilities is the strength of this program.

PITCH IDENTIFICATION drills or tests note names. The computer presents randomly generated notes in Treble and/or Bass clef, and the student types in the letter name on the computer keyboard. The program is well presented but pedagogically weak since students learn notes more efficiently in relationship to each other than by individual identification where students can't use interval relationships.

KEY SIGNATURES presents randomly generated key signatures for the student to identify. The student responds by typing the letter of the key signature and "+" for sharp and "-" for flat. This is a nice drill. The keys are presented Major and minor relative at once, thereby reinforcing recognition of the relationship.

KEYBOARD RECOGNITION drills or tests on identifying a note on the staff with a note on the piano keyboard. The student maneuvers the cursor to the appropriate place on a diagram of the piano keyboard.

INTERVAL DRILLMASTER

Conduit, $75.00

This package provides students with practice in identifying and notating simple melodic intervals. The software includes 22 levels of interval training and gives students the option of taking each level as an assisted drill or a timed test. Students can choose from preset groups of intervals or only intervals of their own choosing. The help screen goes a little too fast. This program has a good recordkeeping feature.

INTERVAL MANIA, MMI, $150. This program requires the MMI DAC Board ($160).

INTERVAL MANIA is a basic drill program presented in a game format where one or two players try to "beat the clock." Students are asked to identify an interval as it is shown or played by the computer. They identify it as Major, minor, augmented, diminished or perfect, and as to its size. The drills are timed and the student is given three chances to get the correct answer. The MMI DAC Board does not perform well for the intervals from 1 to 200 Hz.

KEY SIGNATURE DRILL, MMI, $60. This program requires the MMI DAC Board ($160).

KEY SIGNATURE DRILL provides practice in identifying major and minor key signatures on the treble, bass and grand clefs. The key signature is presented on the screen, and may be accompanied by the computer playing the scale for that key. The student then enters the letter of the key; "S" for sharp or "F" for flat or "N" for natural; and either "J" for maJor or "N" for miNor. This is not standard musical notation.

MAESTROSCOPE THEORY I AND II, Maestro Mu

sic , $300

MAESTROSCOPE THEORY is a very comprehensive program designed to teach basic music theory to children. It presents one concept per lesson and then tests the student on that concept, using True/False or multiple choice questions.

The program is fairly linear in its progression; the user cannot move easily from one lesson to another. This program is not appropriate for the professional level of the USAESOM.

MELODIOUS DICTATOR, MMI, $150. This program requires the MMI DAC Board ($160).

MELODIOUS DICTATOR is designed to teach simple melody dictation skills. The computer plays a simple melody twice and then the user notates it. The dictations are composed by the computer and many lack a sense of musicality. The melodies are all composed in whole notes; this is strictly a melody program, not a rhythm program.

MODE DRILLS, MMI, $70. This program requires the MMI DAC Board ($160).

MODE DRILLS is designed to develop recognition of Major and minor modes and of the five church modes (ionian, dorian, phrygian, lydian, and aeolian). The computer plays a scale and shows the notes on a staff as it plays. The user must then identify the mode. If an incorrect response is given, the computer demonstrates that mode and compares it to the correct one. This is a good program for drill or teaching of modes.

MUSIC IN THEORY AND PRACTICE, MMI, Volume I, $400, Volume II, $275. These programs require the MMI DAC Board.

This series of sixteen disks contains computer-assisted tutorials designed to accompany assignments in Volumes I and II of *Music in Practice and Theory* by Bruce Benward. These programs are designed primarily for college Freshmen and Sophomores. Volume I has twenty chapters--of these twenty chapters, two deal with history, notation, intervals, scales, and keys. The other eighteen chapters are on the study of harmony, and hence not appropriate to this research. Volume II deals with music forms from the Renaissance to the Twentieth Century, counterpoint, fugue, and harmonic analysis. These programs are not directly relevant to the needs of the USAESOM as stated in the contract.

MUSIC LOVER'S GUIDE SERIES, MMI. This series consists of:

General Music Terms, $70

Music Symbols, $70

Standard Instrument Names, $50

Foreign Instrument Names, $50

Composers and Their Works, $70.

These programs all consist of three parts: select-a-term, a multiple choice quiz; spell-a-term, a quiz on the spelling of music terms; and recall-a-term, a quiz on the meaning of music terms. The examples used in these programs offer a good choice of musical terms.

MUSIC MADE EASY, Alfred Publishing Co., available through ECS, $29.95

MUSIC MADE EASY teaches the basics of music in a colorful, fun, step-by-step course. Lessons include: The Staff, Clefs, Measures, Time Signatures, Notes and Rests, Ties and Slurs, Repeats and Endings, Flats, Sharps, and Naturals, Scales and Key Signatures, Dynamics, Tempos, Chords, Inversions, Harmonizing, and Creating Melodies. Each lesson includes drills and quizzes.

MUSIC TERMINOLOGY, ECS, $39.95.

Music Terminology is a set of five individual programs designed to improve the students' knowledge of music terminology. The separate programs include: Glossary of Terms, Categories of Terms, True/False Test, Multiple Choice Test and Fill-In Questions. The program uses a strategy of learning by testing. Each program chooses questions from a pool of over 100 musical terms. A summary of terms to be reviewed is displayed at the end of each program. This is a very useful program.

NAME THAT TUNE, MMI, $75. This program requires the MMI DAC Board ($160).

This is a simple dictation program, which uses well known melodies. The tune is played first one note, then adding another note each repetition. The user is given the chance to enter notes after each playing. This program is a bit simple for the USAESOM.

PATTERNS IN RHYTHM, ECS, $39.95.

PATTERNS IN RHYTHM is an aural-visual program designed to increase memory by allowing the user to compose simple and compound meters. The program offers drill in many time signatures from 2/4 to 12/4. The composer section plays rhythm patterns selected by the user. The dictator section is a quiz which randomly selects and plays rhythm samples for the user to identify.

There are two modes of interaction available, either listening or writing. The user cannot go back and forth between them. This almost forces the listener to use paper and a pencil to write down his notation during the listening mode, so that he/she can remember it during the writing mode, thus defeating the basic purpose of CAI.

The more unusual time signatures are challenging. The program is designed so that the higher the numerator, the more notes fit into an example, hence the more unusual time signatures have more difficult drills. The program would be more supportive and gain pedagogically by presenting short examples of complex rhythms. Scoring takes into account the correctness of the answer and how many times the user listened to the pattern while in listening mode. A perfect score is attained when the user listens to the pattern once and only once. Since it has been established that aural memory can only retain seven items at a time without further rehearsing or chance to group items together, this severe grading can be very discouraging. Students records are retained.

PITCH DRILLS, MMI. PITCH DRILLS WITH ACCIDENTALS, $50
PITCH DRILLS WITHOUT ACCIDENTALS, $50 These programs require the MMI DAC Board ($160).

These programs are designed to improve the user's ability to recognize pitches on the treble and bass clefs, and the grand staff. There are two sections in each

program: note name drills and transposition exercises. Each exercise uses randomly generated notes. The computer shows the note on the staff and sounds the pitch. The user then inputs the letter name of the note. The transposition drills are especially useful for those students who play B flat, E flat and A instruments.

PICK THE PITCH, MMI, $50. This program requires the MMI DAC Board ($160).

"PICK THE PITCH is a note reading drill which will help you read music faster." The computer displays a randomly generated note on the staff and the user identifies it using the letter keys for note names, "F" for flat, "S" for sharp, "FF" for double flat, and "SS" for double sharp. There are five levels of difficulty and two modes: timed game or drill.

RHYTHM DRILLS, MMI, $75. This program requires the MMI DAC Board ($160).

RHYTHM DRILLS is designed to improve the student's rhythmic memory by associating the sound of the pattern with the written notation. The computer plays a melody and the user notates the rhythm pattern using a system of letters to stand for note values: "Q" for quarter note, "H" for half note, etc. Unfortunately, the program also prints the rhythm values as letters and not as notes. (i.e. QEEQH)

RHYTHMIC DICTATOR, MMI, $125. This program requires the MMI DAC Board ($160).

RHYTHMIC DICTATOR is designed to teach rhythmic identification and notation. The program has many levels of difficulty, and automatically moves the student up or down, according to the score on each exercise. The computer plays the rhythm pattern of up to eight measures, then allows the user to notate the pattern. The computer does not play the user's version of the pattern, only the correct version. This is an obvious lack, as students learn much by comparing wrong and right versions using correlation of eye and ear.

SEBASTIAN, MMI, $125. This program requires the MMI DAC Board ($160).

SEBASTIAN is designed to improve the students' ability to detect errors. The computer shows a melody on the screen and then plays the melody with one change in either the rhythm, the pitch or the tempo. The student then isolates the error. The melody can be replayed as many times as the student desires.

SIR WILLIAM WRONG NOTE, MMI, $150. This program requires the MMI DAC Board ($160).

SIR WILLIAM WRONG NOTE is designed to improve the students' ability to perceive errors in four part chords. The user selects the type of chords to be drilled. Then the computer shows a chord on the screen and plays it with one error. Both the example and the student's version can be played as many times as desired.

TUNE-IT II, ECS, $39.95.

TUNE-IT II is designed to give music students practice in matching pitches. This is a useful program, because it gives students a chance to practice tuning with instant feedback. Using a graphic representation of a stringed instrument fingerboard, two pitches are played. The student adjusts the second pitch until it matches the first pitch. There are four levels of difficulty. In the easy levels, tuning is only done by half steps, which is frustrating for musicians, as the starting pitch is randomly generated, so the set halfsteps of the tuned pitch will never meet it exactly.

3.3 SOFTWARE FOR THE IBM PC

Some of the ECS programs for the IBM PC are identical to those for the Apple II, so the reviews for those programs are repeated here.

AURAL SKILLS TRAINER, Electronic Courseware Systems (ECS), set $99.95, each lesson, $39.95. Aural Skills Trainer consists of three lessons: INTERVALS, BASIC CHORDS, and SEVENTH CHORDS.

AURAL SKILLS TRAINER: INTERVALS is designed to improve music students' ability to perceive and identify intervals. The computer plays an interval and the student identifies it.

The interval is sounded only once and cannot be repeated. To enter the name of an interval, the student uses the top row of keys on the computer keyboard. The number of the interval does not correspond to the number of the key. The correspondence is: m2:1 M2:2 m3:3 M3:4 P4:5 TT:6 P5:7 m6:8 M6:9 m7:0 M7:- P8:=. This system creates unnecessary confusion. The system crashes and reboots if any key other than an acceptable response key is typed. There is only one level of difficulty. However, a nice feature of this program is that the student's progress record can be printed.

AURAL SKILLS TRAINER: BASIC CHORDS is designed to improve music students' ability to perceive and identify major, minor, augmented and diminished chords. Since the program uses the IBM PC's internal speaker, which has only monaural sound, it presents the chords in arpeggiated form.

This drawback can be considered a positive factor if the user is new to chord recognition, since it is easier to hear chords in arpeggiated form. The chord is only played once and only one chance is given for a response. A nice feature of this program is that the student's progress record can be printed.

AURAL SKILLS TRAINER: SEVENTH CHORDS is designed to improve music students' ability to perceive and identify seventh chords. This is an ear-training drill similar to BASIC CHORDS. The arpeggiated seventh chord is played and the student is given the choices: major, minor, augmented or diminished. A nice feature of this program is that the student's progress record can be printed.

CLEF NOTES, ECS, $39.95.

CLEF NOTES is designed to improve the speed with which a student can identify music notes as they are placed on the staff, using Treble, Alto, Tenor and Bass Clefs. The program draws a note on the staff in any of the four clefs and the student types in the name of the note, using a movable cursor. The computer marks the answer right or wrong, clears the screen and proceeds to the next example. This program would have a certain limited use for a person who is a beginner at reading notes, but it is not appropriate for the professionally oriented musician.

The main drawback to this program is that it uses randomly generated notes shown one at a time on the staff. This is not an efficient way to learn to read notes. There is only one level of difficulty. At the end of the exercise, the student's score is given in percentages.

CAMUS--MELODIC DICTATIONS, Conduit. Each disk, $50. Set of four disks, $150.
(The following description was provided by the author.)

CAMUS, Computer-Assisted Music Units in Solfege, is a series of 400 exercises for the development of musical skills. Melodic Dictations (a subset of CAMUS) is a set of computer materials to help train the ear to perceive musical sounds in relation to musical notation. The dictations included in the materials address a wide variety of listening problems, such as how to recognize particular intervals, rhythmic intricacies, and mode colors. The primary aim of the dictations, however, is to help student improve their sense of pitch.

The materials are based on the musical discipline of Solfege, which teaches three skills: reading, hearing, and writing. The practice of musical dictation helps students to learn to write music, a skill which requires a synthesis of the reading and hearing skills.

Melodic Dictations contains four disks covering several different levels of difficulty. Each disk contains ten groups of ten dictations. The dictations were created by the author, rather than machine generated, to ensure musically pleasing melodies. Disk #1 dictations are easy enough for high school or university level music students with little experience in ear-training. The melodies in these dictations are made up of simple rhythms, include from seven to twelve notes, and cover all major and most minor keys. Disks #2 and #3 introduce more complex rhythmic notation, chromaticism, and modulations. Disk #4 dictations contain melodies up to eighteen notes long, mostly atonal, and are difficult enough to challenge most advanced music students.

The program is very easy to use. Students can hear the dictation and their own rendition as much as needed to complete the drill. The editor is complete and all commands are on screen at all times. When graded, both versions appear on screen with the grading of pitch and rhythm. The grading and dictation can be printed.

CAMUS--SIGHTREADING IN ALL CLEFS, Under consideration by Conduit, suggested retail price: **$50** .

(The following description was provided by the author.)

CAMUS--Sightreading is the second set in the CAMUS series. It is designed to teach sightreading in all clefs. User may pick one clef to be learned/or practice or a combination of as many clefs as desired. The exercises begin by introducing notes which are points of references, such as C and G. It then proceeds to add notes an interval of a 2nd up or down from these original points of reference, then a 3rd, then a 4th and finally all the notes of the staff. The idea is that it is important to learn reading notes in relationship to each other.

ELEMENTS OF MUSIC, ECS. Each disk: $39.95. Set of three: $99.95. ELEMENTS OF MUSIC is an entry level musical notation program. This series consists of three exercises: Pitch Identification, Key Signatures, and Keyboard Recognition.

The program offers both drill and testing modes. The testing mode can be used with or without a time limit on the response period. Each exercise includes progress tests, progress reports available to the user and an instructor's file for access to all students' records. This set of utilities is the strength of this program.

PITCH IDENTIFICATION drills or tests note names. The computer presents randomly generated notes in Treble and/or Bass clef, and the student types in the letter name on the computer keyboard. The program is well presented but pedagogically weak since students learn notes more efficiently in relationship to each other than by individual identification where students can't use interval relationships.

KEY SIGNATURES presents randomly generated key signatures for the student to identify. The student responds by typing the letter of the key signature and "+" for sharp and "-" for flat. This is a nice drill. The keys are presented Major and minor relative at once, thereby reinforcing recognition of the relationship.

KEYBOARD RECOGNITION drills or tests on identifying a note on the staff with a note on the piano keyboard. The student maneuvers the cursor to the appropriate place on a diagram of the piano keyboard.

MUSIC TERMINOLOGY, ECS, $39.95.

Music Terminology is a set of five individual programs designed to improve the students' knowledge of music terminology. The separate programs include: Glossary of Terms, Categories of Terms, True/False Test, Multiple Choice Test and Fill-In Questions. The program uses a strategy of learning by testing. Each program chooses questions from a pool of over 100 musical terms. A summary of terms to be reviewed is displayed at the end of each program. This is a very useful program.

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There are two modes of interaction available, either listening or writing. The user cannot go back and forth between them. This almost forces the listener to use paper and a pencil to write down his notation during the listening mode, so that he/she can remember it during the writing mode, thus defeating the basic purpose of CAI.

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pitch is randomly generated, so the set halfsteps of the tuned pitch will never meet it exactly.

3.4 SOFTWARE FOR THE MACINTOSH

It has been said that it takes two years for a program to be published after it is submitted to a publisher. The Macintosh is only three years old and challenging to program for, so there are not yet any commercially available Macintosh ear-training or theory programs. This situation will most certainly change in coming years unless programmers are lured away by again newer machines with more versatility. (See chapter 4.)

At Carnegie-Mellon, a series of harmony exercises, called VOICE, is being developed on the Macintosh. The following description of VOICE was supplied by the author, Dr Marilyn Taft Thomas.

VOICE is a program designed to assist music theory students in learning to write four voice chorales according to the guidelines of 17th and 18th century practices. VOICE accepts a list of chords from the user in any Major or minor key and instantly responds with a harmonic analysis and a list of voice-leading and/or doubling errors. The program is fully interactive, permitting the user to fix individual notes, add or delete chords, and even alter the key signature. All changes are immediately reflected in the harmonic analysis and in the list of errors. Students select the key signature and the notes with the mouse, place them or move them around on the musical staff, and listen to the results through the internal sound system. Finished pieces can be printed in actual musical notation.

VOICE was implemented as an integral part of the harmony curriculum in the Carnegie Mellon Music Department in September 1985, and will soon be available through Academic Courseware Exchange Service of Kinko Graphics. (800-235-6919.)

4. OTHER AREAS OF OPPORTUNITY

The contract for this study allows us to "identify areas of opportunity which may arise through the completion of this study."

There are several electronic devices, besides microcomputers, on the market which could be used for music education.

4.1 MIDI

MIDI (musical Instrument Digital Interface) is a system which allows computers, synthesizers, sequencers and signal processors to be interfaced together in a simple, standard and economical way. MIDI is a new technology which presents challenges to programmers. Therefore, the choice of software developed for its use is limited. Almost all synthesizer keyboards today have MIDI capability. The MIDI system is preferable to a synthesizer board because it is so flexible. Using MIDI, a microcomputer can be interfaced with *any* keyboard, allowing for a great variety in sound and sound quality. This means that exercises can be designed for theory or ear-training that use the synthesizer keyboard to play an answer to a question. It means that sound boards are not a problem anymore, if the cost of a synthesizer can be afforded. Programs for MIDI is being designed that will help programmers to write educational software, using other peripherals as well, such as pitch extractors. The MIDI is the to be watched carefully for truly creative potential CAI in music in the next few years.

4.1.1 MIDI for the APPLE

MIDI (Musical Instrument Digital Interface) is a system which allows computers, synthesizers, sequencers and signal processors to be interfaced together in a simple, standard, and economical way. The MIDI system allows the Apple to control a conventional music synthesizer. The sound produced by the Apple II through a MIDI

synthesizer combination is of much better quality than the sound of any of the sound synthesizer boards.

4.1.2 MIDI for the MACINTOSH

In addition to the good built-in sound, the Macintosh is MIDI compatible. MIDI interfaces for the MacIntosh are made by many companies, including well known ones such as Roland and Cherry Lane.

4.1.3 MIDI for the IBM PC

The only IBM MIDI interface on the market is made by Roland Corporation. It is much more sophisticated than the MIDI interfaces available for the Apple. In fact, some of its features, such as multitrack sequencing (where the computer plays back several different tracks at the same time which have been put into its memory separately) or the ability to interface with several instruments at the same time, are unlikely to be used by a music instruction program as their architecture far exceeds the needs of instructional design. The Roland MPU-401 with cables and IBM interface card costs $310.

4.2 MIDI SOFTWARE

KEYBOARD BLUES-MIDI, ECS, $79.95. This program requires a Passport MIDI card ($149.95).

KEYBOARD BLUES presents simple blues chords. The student is introduced to the twelve bar blues and can practice playing and hearing the chord changes, first with the music and then without. The drill and practice section scores the students knowledge of the simple blues chords. The student may then compose an original blues solo with an accompaniment. The computer does not grade these solos.

KEYBOARD JAZZ HARMONIES-MIDI, ECS, $79.95. This program requires a Passport MIDI card ($149.95).

Keyboard Jazz Harmonies is designed to teach chord symbols, seventh chord recognition, and chord spelling. To use this lesson, a basic knowledge of traditional harmonies and musical intervals is required. The program consists of a tutorial, four drills, and a final quiz.

4.3 MUSIC TRANSCRIPTION PROGRAMS

Besides CAI in music theory and ear-training, the USAESOM could use computers for music transcription.

Transcription on the IBM PC

There are two transcription programs available for the IBM PC: MPS (Musical Processing System) and the Personal Composer.

MPS, Roland, $450. This program requires MIDI.

MPS (Music Processing System) combines the functions of editing, recording, and playing back of MIDI performance data, with those of transcribing and printing the data in musical notation.

MPS performs the first set of tasks as if it were an 8-track MIDI recording studio. Pieces of music can be edited on the measure by measure level, allowing the user to cut and paste measures into the desired arrangement. Music can also be edited on a note by note level on screen, using musical notation. Only one measure of music can be shown and edited in notation at a time.

MPS is not a very efficient system for transcribing and editing music. The amount of work the user is required to perform is as great as if he/she scored by hand.

Although tedious to learn to use, MPS is a good tool for recording and sequencing. But, it is mediocre for music transcription.

Personal Composer, $450. If transcription must be done on the IBM PC, then Personal Composer is our preferred choice, but the results will not be as elegant as those obtained on the Macintosh with the Professional Composer.

The Apple Macintosh has by far the most numerous programs available in this specialty. The constraints of this study did not allow us to review many of these programs, so we are reproducing, with permission, some of the reviews from the ATMI (Association for Technology in Music Instruction) Newsletter, Volume IX, Number 5, October, 1985. ATMI reviews are identified as such at the beginning of each review.

CONCERTWARE, Great Wave Software, $49.95
ATMI Review

"The package is made of three programs, Writer, which is a music editor, Instrument Maker, an interface to the built-in synthesizer, and Player, for playback of works entered with the Writer program. Thirty-three sample works are included as well as thirty-four predesigned instruments.The program is operated from the mouse and uses a number of icons to control the software. Notes, for example, are entered by first using the mouse to click on a rhythmic value and then to click on the desired note or rest in the next iconographic section. According to Yavelow[16] 'I would say that this program is well worth the money. It is of little use to the professional copyist but all other music hobbyists should find it very interesting. Finally, as an educational tool for the study of acoustics, the Instrument Maker is quite valuable.'"

MACMUSIC, Utopian Software, $89.95
ATMI Review

"This program, like the previous one, has three parts, Music Editor (corresponding to the previous Writer), Music Player, and a Waveform Editor. Unlike ConcertWare, however, these programs are carefully integrated into a single package. There is no attempt to allow for entering of scores with hardcopy in mind. It is purely a playback or performance package. Its real strengths lie in the possibilities for creating 'real music' that is not concerned with traditional music notation. Two very

slick features of MacMusic are the ability to call nested subroutines (up to 16 levels deep!) and the ability to utilize duration values that are not powers of 2. Unfortunately, MacMusic does not allow the user to 'see' more than one voice at a time, and has a manual that could be confusing."

MUSPRINT, Keith Hamel, $79.95

ATMI Review

"'MusPrint is a music editor that, unlike all the other programs reviewed herein, with the exception of Music Character Set, does not "understand" music. That is to say, it thinks of the music as purely graphic images - a MacPrint bitmap, to be precise. This notwithstanding, the graphics produced by MusPrint are by far superior to those produced by any of the other programs reviewed. It is possibly the slickest. fastest program ever written in uncompiled Basic (Microsoft Basic) and runs in conjunction with MacPaint.' That opening probably says almost all you need to know about this program. It was designed for expert music printing, and allows for practically every notational convention you can think of, including beams, slurs, bow markings, trills and octave signs. Entry is done with the mouse, and is quite simple, and the manual, which is reported to be good, is very necessary."

MUSICWORKS, Hayden Software, $46

ATMI Review

"MusicWorks is easy and fun, and the excellent manual helps users get through the program with no pain. Again, it uses an iconographic approach to the entry of music, and offers two ways to enter notes, on a staff or on a graphic representation of a grid similar to a keyboard. Little musical knowledge is required in order for the user to enjoy the program. According to Yavelow,[16] 'MusicWorks makes use of all the standard Macintosh user interface features at every level... In fact, if the user is conversant with MacWrite or MacPaint he will find that he has no problem using

MusicWorks immediately and may never have to refer to the manual.' His conclusions that 'MusicWorks is an entertaining and powerful program, with many educational possibilities, guaranteed never to pale with repeated use. At the extremely reasonable price of $46 it may well be the best dollar-for-dollar software value that is available for the Macintosh in any field, music or otherwise. My personal opinion is that is a must-have for all Macintosh owners.'"

PROFESSIONAL COMPOSER, Mark of the Unicorn, $495

We had heard some extraordinary reviews of the Professional Composer, including that it was "Macintosh Music Program of the Year". In his review, Yavelow[16] states that the Professional Composer provides a quick and easy way for the professional musician to enter and print musical scores of up to forty staves per system as well as extracting parts and making piano reductions.

I must take exception to "quick and easy." Professional Composer is neither quick nor easy. It is exact, and it is esthetically pleasing, but easy it is not. It has a complete palette of musical symbols. It took me several times longer to enter three or four bars of music on the Macintosh than it would have taken me to write them out by hand on paper.

Interestingly enough, version 1.1 has a "faster way" to enter notation: instead of clicking the mouse, one types the names of the notes A to G right on the keyboard, following each letter by "enter". When using the mouse to enter notes, it is easy to go too fast and overshoot the line or space intended, therefore getting the wrong note.

Reducing a piece to the piano score is very difficult to do. It will not print a grand staff, only either bass or treble. Also, the different parts pulled together do not line up correctly; stems go into each other and rests create havoc.

In spite of all these bugs, Professional Composer remains a superb editing program, by far the most professional. It is easy to understand the enthusiasm of Christopher Yavelow and the ATMI review.

ATMI Review

"This program won *A+* magazine's "MacIntosh Music Program of the Year" award as one of the reader's poll twelve best programs for the MacIntosh *before it was released to the public!* This gives a good idea of the quality of this program. It is designed for the professional copyist, and could easily replace ink pens and onionskins forever. (A better name for the program might be "Professional Copyist".) According to Yavelow[16], 'It is the grand-daddy of all current MacIntosh music programs and its position is not likely to be eclipsed within the foreseeable future." Some of its features include one to forty (40!) staff scores, automatic transposition, automatic part extraction, automatic creation of a piano reduction,MIDI interface capability, changing meter, and rebarring. Yavelow concedes that '...for the professional musician, the Professional Composer software package alone could justify the purchase of a MacIntosh computer...It is that powerful. Bravo!'"

4.4 RECORDKEEPING SOFTWARE

There are several programs available which serve to keep records along with or instead of a teachers record book. Some are not designed specifically for use by teachers, but have the necessary capabilities. General spreadsheet programs such as VISICALC or LOTUS 1-2-3 can be used for this task.

COMPUTERIZED GRADEBOOK, ECS, $50. This is an excellent, clear, easy-to-use, comprehensive recordkeeping program. The features include final score, letter grade, roster by name or grade, and printed reports. The Apple version holds 50 names with 10 scores each. The IBM version holds 75 names with 32 scores for 9 different classes. The records are retained on one disk with password security.

KALAMAZOO TEACHERS RECORD BOOK

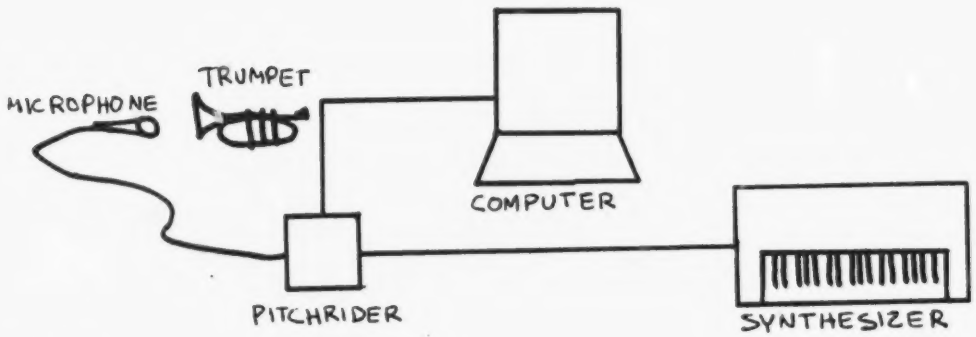
The Kalamazoo Teachers Record Book offers several statistical features. It allows the teacher to store and update student data on a floppy disk. It computes averages

and grades, with a standard deviation and a weighted average. It can print students' grades, records and reports in several different formats. It can display student data by category. It will also produce a bar graph of student scores.

4.5 PITCH DETECTORS

Pitchrider

The Pitchrider is a sound measuring device which determines the pitch of a note. The sound source can be a voice, an instrument or anything that produces tones. The Pitchrider was designed for instruments, playing one note at a time. It is not really accurate for voices; it is too sensitive to the many shapes of sound waves produced by the voice, so it gives erratic readings. The pitchrider has a built-in microphone which picks up sounds. The Pitchrider also accepts input from electric instruments or instruments with transducer microphones attached. The Pitchrider displays the name of the note being played, its octave and a bar graph depicting the intonation of the note. In addition, the Pitchrider generates MIDI information for the notes it receives, allowing any instrument to control synthesizers through the Pitchrider. The pitchrider can transpose the notes it receives. It is possible to write computer programs which allow melodic drills written on the computer to be used with the Pitchrider.



Pitchmaster

The MMI Pitchmaster is designed as a diatonic series sight-singing tool. The Pitchmaster compares the user's performance of singing with sounds from a

prerecorded cassette and indicates how accurate the performance is, both in pitch and in tuning. In addition to published lessons available for the Pitchmaster, there is a special feature allowing the a user to make his/her own tapes. The lessons are very easy to follow and pleasant to use. Although the Pitchmaster helps to place the voice, there is no direct instruction for learning to read notes. This is an electronoc device, not a computer, consequently it is more a programmed text book with tapes. The companion series to Pitchmaster is Tapmaster, a rhythm program of the same type as Pitchmaster.

4.5.1 CASIO CZ-101 AND CZ 1000 SYNTHESIZERS

The only difference between the CZ-101 and the CZ-1000 is the size of the keyboard. The Cz-1000 has full sized keys like a piano keyboard, whereas the CZ-101 has smaller toy-like keys. This explains the difference in price. The CZ-101 lists for $499 and can be bought at discount for $375. The CZ-1000 lists for $699 and can be bought at discount for $499.

Casio Memory

The CZ series has an internal memory capable of storing 16 user defined sounds in addition to 16 preset sounds. The presets are not user defined; they cannot be changed. The Casio also has a slot for a RAM (random access memory) cartridge which can hold another 16 sounds.

Casio Keyboard

The Casio keyboard covers four octaves, from C to C. This does not mean that the range is limited to those notes in the four octave span of the keyboard, because the octave can be scaled up or down for different pitches.

Casio MIDI

The Casio can send and receive a subset of MIDI messages on any one of 16 MIDI channels.

Casio Multi-Timbral Capability

The most important feature of the Casio is its ability to perform with four independent voices, each having its own sound setting. For example, a tuba, a trumpet, a violin and a piano could be played independently to form a "synthesized quartet". This capability is called "multi-timbral", and would be useful for arranging or composing four part music. A computer or sequencer could store the score, sending the appropriate information to the Casio through MIDI.

Casio Sound Storage on Computer

Another useful feature of the Casio is its ability to store sound information externally. Rather than store different sound patches (the settings for the voices) in RAM cartridges, the Casio can store them on the computer. MIDI signals can be sent and received describing all the sounds necessary to create a particular sound. When interfaced with a computer, the MIDI information about different patches can be stored as files on a floppy disk.

Hardware Specifics of the Casio

The Casio is a digital synthesizer capable of eight voice polyphonic sound with one oscillator per voice, or four voice polyphonic sound with two oscillators per voice. Almost all sound patches created for the Casio use the four voice mode, since having two oscillators per voice produces a very rich sound. When not using two oscillators per voice, the sounds produced are a bit thin. Each of the two oscillators (per voice) can be assigned separate waveform, modulation, dynamics and filter settings. There are separate envelope generators for pitch, filter and dynamics. Each can be up to eight stages long, allowing for very sophisticated sound shaping. There is a vibrato control with programmable delay, rate, depth and waveform. The two oscillators can be detuned, ring modulated or noise modulated to produce clangorous sounds such as bells or tuned percussion. Portamento (pitch glide) is also available. Overall, the Casio CZ series synthesizers are very sophisticated and well suited for performance in popular music making as well as for a sound source in music instruction.

4.6 NEXT GENERATION MICROCOMPUTERS

Having evaluated the machines specified in the contract, we want to mention new machines which will surely change the total picture of CAI in music in the next few years. Two machines are just entering the market that compare favorably with the Macintosh and the IBM PC. They are the Commodore Amiga 1000 and the Atari 1040 ST. The new Amiga and the new Atari use the 68000 Microprocessor, which the Macintosh uses. It is a fast and powerful chip. Both the Atari and the Amiga incorporate color graphics with maximum resolution of 640 by 400 pixels, which the Macintosh does not have. The Amiga has a 256K memory which is expandable to 8 megabyte (approximately 8,000K), while the Atari has 1 megabyte (1,024K) memory. The Amiga has sound capabilities similar to those of the Macintosh, but of higher quality. The Amiga has sound capabilities closer to the IBM PC, but it also has MIDI in and out ports, eliminating the need for a MIDI interface.

(We received permission from the Amiga magazine editors to reproduce the following comparative chart.)

	Amiga	*Mac*	*IBM PC*	*PC AT*
Microprocessor	68000 Motorola 16/32 bit	68000 Motorola 16/32 bit	8088 Intel 8/16 bit	80286 Intel 16/24 bit
Speed	7.8 MHz	7.8 MHz	4.77 MHz	6 MHz
Memory	256K RAM 192K ROM	128K RAM 64K ROM	64K RAM 40K ROM	256K RAM 64K ROM
Expansion (useable RAM)	Up to 512K (external—up to 8 MB)	Up to 512K	Up to 640K	Up to 3 MB
Disk Capacity	880K 3½"	400K 3½"	360K 5¼"	1.2 MB 5¼"
Video Display	RGB Composite Color TV	Monochrome	Monochrome	Monochrome
Color	Yes 4,096 colors	No (black & white only)	Separate color card[1] 16 colors on one screen	
Highest Color Resolution	640 x 400	512 x 342	640 x 350[1]	640 x 350[1]
Keyboard	89 Keys Numeric Pad	58 Keys	82 Keys Numeric Pad	84 Keys Numeric Pad
Speech Synthesis (built-in)	Yes (unlimited text to voice)	No	No	No
Music	4 channels[2] (stereo)	1 channel[3] (monaural)	1 voice	1 voice
I/O Ports (built-in)	RS 232 Parallel Serial	Serial	No	No

[1]Not included in IBM PC and PC AT basic units.

[2]The Amiga has four hardware audio DMA channels, which feed two stereo output ports. The processor is not accessed for sound generation.

[3]The Macintosh has four software-driven voices, which use over 50% of the processor's time.

5. COST ESTIMATES

5.1 HARDWARE COSTS

The following figures are those from reputable dealers. Some figures reflect special sale prices. These figures are all based on buying a single item. Consequently, we can assume that if we were to order multiple units, we would be able to obtain lower prices for each work station than those calculated in this estimate. According to the contract the minimum requirements for a machine are the ability to play single note melodies, run complex programs, show music graphics on screen and print a copy of the exercise with a grading record. We have included costs of printer for the Apple II, but have found that some of the programs we recommend as being best suited to the educational needs of the USAESOM do not necessarily have printing capabilities. This is because so many programs for the Apple II were written before it had enough memory space to implement every nice feature, and many designers were obliged to sacrifice printing features.

APPLE II

APPLE II WITH MINIMUM REQUIREMENTS	
Apple IIe with 128K RAM, two disk drives, memory expansion board, and monitor	$1550
Imagewriter II, (dot-matrix printer)	$495
Printer cable	$30
Printer card	$139
Earphones	$20
Apple II with minimum requirements, total	**$2234**

APPLE II WITH SOUND BOARD

Apple IIe with minimum configuration	$2234
Choice of Music Board, up to	$395
Apple II with Music Board, total	**$2629**

APPLE II WITH MIDI AND SYNTHESIZER

Apple IIe with minimum configuration	$2234
MIDI for Apple IIe	$149
MIDI cable	$38
Casio Synthesizer	$400
Apple II with MIDI, total	**$2821**

MACINTOSH

MACINTOSH WITH MINIMUM REQUIREMENTS

Macintosh computer with 512K RAM, monitor and one disk drive	$1595
Imagewriter (dot-matrix printer)	$495
Printer cable	$30
Earphones	$20
Macintosh with minimum requirements, total	**$2140**

MACINTOSH WITH MIDI

Macintosh with minimum configuration	$2140
MIDI for the Mac	$89
MIDI cable	$38
Casio Synthesizer	$400
Macintosh with MIDI, total	**$2667**

IBM PC

IBM PC WITH MINIMUM REQUIREMENTS	
IBM PC computer with 256K RAM and two disk drives	$2295
AST 6-PAK Memory Board	$384
Hercules Graphics Board	$245
Color Monitor (necessary for graphics)	$680
IBM ProPrinter (dot-matrix printer)	$400
Printer Cable	$56
Earphones	$20
IBM PC minimum requirements, total	**$4080**

IBM PC WITH SOUND BOARD	
PC with minimum configuration	$4080
University of Delaware Sound Board	$300
IBM PC with sound board, total	**$4380**

IBM PC WITH MIDI AND SYNTHESIZER	
PC with minimum configuration	$4080
Roland MIDI Interface	$160
MIDI Music Box	$88
MIDI cable	$38
Casio Synthesizer	$400
IBM PC with MIDI and synthesizer, total	**$4766**

WYSE PC

WYSE PC MINIMUM REQUIREMENTS

Wyse PC	$1264
Multi-function Back Plane	$190
Color Graphics Board	$395
Color Monitor	$745
Printer	$549
Earphones	$20
Wyse PC with minimum requirements, total	**$3163**

WYSE PC WITH SOUND BOARD

PC with minimum configuration	$3163
University of Delaware Sound Board	$300
Wyse PC with sound board, total	**$3463**

WYSE PC WITH MIDI AND SYNTHESIZER

PC with minimum configuration	$3163
Roland MIDI Interface	$160
MIDI Music Box	$88
connecting MIDI cable	$38
Casio Synthesizer	$400
Wyse PC with MIDI and synthesizer, total	**$3849**

Note: In order to use both MIDI and a sound board at the same time with the Wyse PC, it is necessary to use an expansion chassis which contains 4 more slots. The expansion chassis costs $365.

Clarification: earphones

Adding a jack for earphones to a machine that does not come equipped with one is a fairly simple procedure for anyone who has some knowledge of electronic equipment. We recommend earphones with small amplifiers built-in, available commercially for $20. If a machine like the Wyse or the IBM PC is selected there will be a noise problem when more than one machine is in use at a time. If each band has only one machine, then there is only the annoyance to the user of external noises. But if more than one machine is installed in a lab, and hopefully as many as four or five, as the USAESOM will require to serve the student body, then it is imperative that wiring to the speaker be devised until the time when there are other means of isolating users from sound pollution. By other means I am speaking of either MIDI sound which has phone jack attachment, or sound board. Right now there is no educational software marketed for these devices. The University of Delaware has ported its ear-training series Guido for their new sound board and lent it to us for review, but technical problems prevented us from testing the software.

5.2 SOFTWARE COSTS

Much software has come out on the market since 1980, but some of the problems remain. It would be easier to build a varied CAI library of software if we weren't limited by the choice of hardware. We hope the time will come when software will run on any machine. At present, even with the educational software available for the Apple II, once it is classified according to what synthesizer it needs for audio output, the choice becomes really quite limited.

The following figures compile recommended libraries of software for the USAESOM and the reserve bands' training. They are divided by microcomputer and other hardware needed to run them. So, there is a recommended set for Apple II with minimum configuration, for Apple II with Sound Board, and for Apple II with MIDI.

SOFTWARE FOR THE APPLE II

Recommended software, listed by publisher in alphabetical order for the Apple II with minimum configuration

CAMUS--Melodic Dictations	Conduit	$150 (4 disks)
CAMUS--Sightreading	Conduit	$50
Interval Drillmaster	Conduit	$75
Patterns in Rhythm	ECS	$40
Elements of Music	ECS	$100
Aural Skills Trainers	ECS	$100 (3 disks)
Music Terminology	ECS	$40
Computerized Gradebook	ECS	$50
Catch the Key	MMI(+DAC board)	$210
Mode Drills	MMI(+DAC board)	$230
Total		**$1050**

Note: The Mountain Music Board is optional but desirable with CAMUS--Melodic Dictations.

There is no music education software for the Macintosh that we would recommend as fulfilling the needs of the USAESOM or the Reserve bands. For transcription purposes we recommend The Professional Composer, $400.

SOFTWARE FOR THE IBM PC

Recommended software(by publisher listed in alphabetical order for the IBM PC with minimum configuration)

CAMUS--Melodic Dictations	Conduit	$150 (4 disks)
CAMUS--Sightreading	Conduit	$50
Patterns in Rhythm	ECS	$40
Elements of Music	ECS	$100
Aural Skills Trainers	ECS	$100 (3 disks)
Computerized Gradebook	ECS	$50
MPS MIDI	Roland	$450
Total		**$940**

All of the software recommended for the IBM PC will run on the Wyse PC.

5.3 INSTALLATION AND OPERATING COSTS

Installation cost

The cost of installing a microcomputer music lab has been discussed previously. (See chapter 1, page 11) Because the installation cost varies so much from facility to facility, it is not possible to give an exact figure here.

Paper

Printer paper comes in boxes of 2700 sheets. If 100 users print one exercise or set of grades each week for a year, they will use two boxes. If the printer is also used to print music scores, the amount of paper needed will be more. Each box costs $25. I suggest $100 a year for paper use. This will not cover extra programming use or text editing.

Disks

Most software is copy protected and cannot be copied. Usually software handled in a reasonably careful way lasts though many runs. We have indicated a list of software for a starting library. An extra two boxes of empty diskettes will take care of any special needs which arise, such as copying programs that are in the public domain, and adding dictations to programs which have authoring systems. Each box of disks costs $25.

Yearly upkeep costs

Once a choice of hardware and software has been determined, an upkeep allowance of 10% of the purchase price of hardware and software should be calculated for yearly upkeep and maintenance. This figure is adequate for all repairs and replacements of hardware and software. Approximately $150 of paper and diskettes is estimated per machine per year.

Not included in the calculations are costs for installation, (as mentioned above), personnel for monitoring the lab, or utilities and other overhead involved in running the lab.

MICROCOMPUTER SYSTEMS COMPARISON CHART

Minimum configuration with no sound board, adequate but different amount of memory memory, according to needed software available

	APPLE II	MACINTOSH	IBM PC	WYSE PC
Hardware	$2234	$2140	$4080	$3263
Software	$1050	-----	$940	$940
Total	$3284	$2140	$5020	$4203

To the above configuration, if we add a sound board, averaging $300 each:

	$3584	N/A	$5320	$4503

To the minimum configuration instead of a soundboard, if we add MIDI equipment and a $400 synthesizer: (The choice of software varies greatly, consequently no cost is included in these figures)

MIDI	$590	$520	$690	$690
TOTAL	$3874	$2660	$5710	$5193

The cost for upkeep can be estimated at 10% annually of the above figures.

6. SUMMARY AND RECOMMENDATIONS

6.1 SUMMARY

Apple II

The Apple II family has been a superb family. It represents an era of computing which was the beginning of a new creativity. It pointed the way to new potentials in hardware and software developments. In 1986, if I had an Apple IIc, I would not stop using it as long as I could maintain the hardware as needed. But, in 1986, I would not buy an Apple IIc for music education, because, it has had its day and the technology to which it pointed the way is now coming into its own.

Music software for the Apple II is varied, as demonstrated in chapter 3. But much of this software was developed for reasons which do not relate to the needs of the USAESOM. Much of it is not worthy of the name "Educational Software." Some of it was designed by people more interested in commercial success than in service to musicians. Very little of it was designed by professional programmers working with professional music instructors and repeatedly tested in an educational setting. So, in spite of the large impressive list of Apple II software to choose from, we are left with a rather small choice once we attempt to match specific needs with available software.

Macintosh

The Macintosh has captured a large audience of rather fanatic followers. Its arrival, more than that of any other machine, has separated microcomputer users into two camps: those who do not mind spelling D for Delete and C for Copy, and those who would rather handle symbolic icons. As a person who feels that learning to spell and to type is useful and not unduly demanding, I belong to the first group. I do not like having to go to a menu of commands, clicking a mouse to choose and go back to

the exact item to be altered in order to delete this item. I feel that typing D for Delete is much easier, faster, and efficient. I realize that many people are more visually oriented and like the windows and icons of the Macintosh environment. I do not like having all those little boxes cluttering the screen all the time. Why have the boxes of commands taking up screen space when we have brains which can store data such as D for Delete?

The screen of the Macintosh looks crisp and clean. The designers have very cleverly taken the same resolution as that of other machines but, by reducing the size of the screen, and keeping approximately the same number of pixels, they obtained a neater picture. However, it does look small and there are complaints about the optical fatigue it inflicts on the user.

In spite of its better than average built-in sound capability, there is as yet no music education software for the Macintosh. But if the USAESOM is interested in music transcription programs, (See chapter 4), the Macintosh has superior software for this purpose.

IBM PC and Wyse PC

The last machine included in this study is the IBM PC/Wyse PC. The IBM PC and the Wyse PC have almost identical specifications. The Wyse has fewer slots built-in, but that can be remedied by adding an expansion chassis which has 4 slots. The sound capabilities of the IBM PC are like those of the Apple II: square waves produced on the internal speaker. Consequently, the sound quality does not encourage music software development. The IBM PC is not a machine that is likely to disappear in the foreseeable future, as some other machines of lesser reknown.

Right now, the list of available software for the IBM PC/Wyse PC useable at the USAESOM is limited. I would suggest however that there is enough software for the IBM PC to start on a program of computer music instruction. (See prices and list of suggested material in chapter 5.)

6.2 RECOMMENDATIONS

I suggest that the Army acquire IBM PC microcomputers (or Wyse PC's as second choice) for music instruction and Macintosh microcomputers for music transcription. The minimum number of machines for music instruction should be one workstation to every 20 students. This would average to 2 machines for a band of 41 players and 3 machines for a band of 65 players. Each machine would be equipped with a printer and, hopefully, with MIDI equipment and synthesizer. In addition, each band should have 1 Macintosh and Imagewriter for transcription work. The USAESOM should have one IBM PC for every 20 students. The computer lab should also be equipped with printers, synthesizers, earphones and software. (See chapter 5 for costs.) The school should also acquire a minimum of two Macintosh computers with printers for transcription.

To get started on a CAI program at the USAESOM, the programs suggested will be a good investment. But I would like to suggest that for longer range planning, rather than invest money in commercial programs that are only approximately suited to the needs of the School, specific CAI programs should be designed in close cooperation with the instructors at the School.

There are several areas of instruction which have yet to be explored in CAI which are the backbone of any music school, including the USAESOM.

1. Basic theory, taught, not just quizzed on. A student who does not know the system and logic of tetrachords and key signatures will not learn these fundamentals by quizzes on that subject, although the student might memorize the right answers. Computer Based Instruction can fill gaps of knowledge but takes time to program and therefore has not been addressed by music software developers.

2. Pitch singing. Most schools, including the USAESOM, use the voice in class to sing triads and melodic lines. No commercial software exists that reinforces these skills learned in the classroom.

3. Rhythm study. Much remains to be done in this area as well: error detection, reading and dictation. We designed a prototype exercise of "related rhythms" which parallels one of the exercises practiced at the USAESOM. This is only a small example of the custom software that could be developed for the USAESOM.

It is not enough to have hardware and software in a lab. If the software is too general in its approach, we found that students will not spend the necessary time or degree of involvement that they would devote to specifically designed software. Yet, a good library should include general as well as specific types of literature. By combining specific software and more general software, the USAESOM will have a library of software that can be a model in CAI in music, filling a great need in the domain of music education.

I want to end this report by expressing my thanks to those responsible for giving me the opportunity to conduct this research. It has been a pleasure to work on a project which is so timely and the results of which are in constant demand.

Oral report and demonstration of software and hardware given on March 12 1986 at the USAESOM, Amphibious Base, Norfolk, Virginia

- Resume of printed report
- Slide presentation of examples of software for CAI in music and of music transcription software for the IBM pc and for the Macintosh.
- Hands-on demonstration of:
  - Apple IIe: Intervals drills and from Conduit and MMI
  - IBM pc: Prototype program of related rhythms. Melodic Dictations from Conduit. Sight-Reading from CONDUIT. ECS programs in general theory, Grade book.
  - Wyse 6000: Same software as IBM pc
  - Macintosh: Professional Composer, De Luxe Construction set.
  - Pitchrider
  - Midi equipment with synthesizer for the Apple IIe, the IBM pc and the Wyse. ECS for the Apple IIe, MPS for the IBM and Wyse.
  - Printing of various CAI and transcription programs on the Proprinter and the Imagewriter.

Inventory of software and necessary peripherals left at the USAESOM for further testing:

For Apple IIe:

1. Music Made Easy ECS
2. Midi Jazz Harmonies ECS
3. Keyboard Jazz Harmonies-MIDI ECS

For the IBM pc/Wyse

1. Prototype program for " Related Rhythms Exercise"
2. CAMUS Melodic Dictations CONDUIT - 4 disks.
3. Patterns in Rhythms ECS -
4. Elements of Music ECS
5. Aural Skills Trainer ECS
6. Tune It II ECS
7. Music Terminology RCS
8. Computerized Grade book ECS
9. MPS (Transcription MIDI Program) Roland.
10. Personal Composer. Passport

for the Macintosh

1. Professional Composer
2. Deluxe construction set.

Photos

Two sets of 100 slides each of software on screen for purpose of later demonstrations with descriptive listings.

I. LEXICON OF COMPUTER TERMS

ALPHANUMERIC	Using the letters A-Z, the numerals 0-9, and other symbols (*&,$).
ARCHITECTURE	The internal arrangement of a computer or part of a computer.
AUTHORING LANGUAGE	Programming language with codes specifically designed to handle major courseware needs.
AUTHORING SYSTEM	Prepackaged software designed to help authors create their own programs.
AUTHORS	One who designs software.
BOOT	To enter systems software into a computer system.
BYTE	A group of binary bits. Usually eight. Usually equal to one character.
CHARACTER	A symbol which conveys a piece of information.
CHIP	An integrated circuit or the piece of silicon on which it is manufactured.
COMMAND	A program instruction.
COMPATIBILITY	The ability of hardware components to be directly connected. The ability of software to run on certain hardware.
COMPUTER	An assembly of switches that can be programmed to process information.
COMPUTER-BASED-EDUCATION (CBE)	The use of the computer to support the education process.

COMPUTER-ASSISTED-INSTRUCTION (CAI)	The use of the computer as a teaching tool.
CONFIGURATION	The design of a computer system.
COURSEWARE	Programs designed to teach educational content.
CURSOR	Symbol, usually a flashing square, which indicates where the next input will appear on a visual display screen.
DATA	Elements for storage or manipulation by the computer system, expressed in character form.
DIGITAL TO ANALOG CONVERTER (DAC)	A component which transforms digital data to an analog equivalent.
DISK DRIVE	A component on which disks are run.
DISK OPERATING SYSTEM (DOS)	Program which carries out the transfer of data between the CPU and disk storage.
DOT MATRIX	A printing system in which each letter is composed of a matrix of dots.
EDIT	To change a program or file.
EDITOR	Program used as a tool to edit other programs.
FILE	A collection of related data stored in a given place.
FRAME	One screen, display, concept or interaction within a programmed instruction lesson.
GRAPHICS	Screen displays which are not text: pictures, charts or other drawings.
HARDWARE	The physical equipment of a system, as opposed to software.

INPUT	Data entered into a computer.
INPUT BUFFER	A space in the memory for characters awaiting input.
INTERACTIVE	A system which allows for two-way interaction between the computer and the user.
INTERFACE	The connection between two components of the computer system.
KEYBOARD	The component, ressembling a typewriter, used to enter data.
K or KILOBYTE	1,024 (2 to the 10th power) bytes.
LOAD	To transfer a program from the disk where it is stored to the Random Access Memory, where it can be used.
MAINFRAME	A large computer.
MEGABYTE	1,048,576 (2 to the 20th power) bytes.
MEMORY	The place in which data is stored.
MENU	A list of user options that corresponds to the branches of the program.
MICROCOMPUTER	A small computer.
MICROPROCESSOR	Central processing unit contained on a single chip.
MIDI	Musical Instrument Digital Interface. A convention which allows computers to communicate with electronic instruments.

MNEMONIC	Assisting the user's memory.
MONITOR	The video display unit.
ON-LINE	Immediately available for use by the computer. Does not have to be loaded.
OPERATING SYSTEM	Internal program which controls the system.
OUTPUT	Data emitted from the system.
PERIPHERAL	A hardware device that can be attatched to and operated in conjunction with a computer.
PIXEL unit	PICture ELement. Tiny portion of a video screen. One of graphics.
PORT	Connection point for peripherals. To translate a program from one computer's format to another's.
PROGRAM	A sequence of instructions.
PROGRAMMED INSTRUCTION	A type of instruction wherein the instructional content is broken down into small steps which proceed logically from first to last.
RAM	Random Access Memory.
RESOLUTION	The clarity of the picture on the monitor. Usually measured in pixels.
RESPONSE TIME	The time it takes the CPU to respond to instructions.
RUN	Execute a program.
SLOT	A place in the computer to insert a card, board or chips.

SOFTWARE	Programs.
STANDARD	Widely observed practices in hardware or software specifications.
STORAGE DEVICE	A place where data can be stored.
SUBROUTINE	Part of a larger program that can be called up as a unit and repeated as and when necessary.
SYSTEM STACK	memory space for temporary storage needed by the CPU.
TURN KEY SYSTEM	A computer that is ready to be used for a particular application when it is turned on. It requires no other hardware or software.
USER FRIENDLY	Easy to use.

II. RESOURCES

CATALOGS AND REVIEWS

Courseware Directory, Colette Jousse Wilkins, editor, published by the National Consortium for Computer-Based Music Instruction (NCCBMI), 1984.

Music Programs for the Apple Computer, Fourth Edition, A directory of Computer-Assisted Instructional Materials in the Field of Music Education. Compiled by Denis C. Moreen, College of Notre Dame, July 1984.

JOURNALS

ACH Newletter, published by the Association for Computers in the Humanities.

Infoworld, a weekly publication of general microcomputer news.

ISME Yearbook, published by the International Society for Music Education, Department of Music, University of Western Australia.

Journal of Computer-Based Instruction, published by ADCIS (Association for the Development of Computer-based Instructional Software).

Music Theory Research Newsletter, published by the Consortium for Studies in Music Theory at North Texas State University.

Wheels for The Mind, An Apple University Publication Prepared at Boston College, published by Apple Computer, Inc.

OTHER RESOURCES

ERIC, The Educational Resource Information Clearinghouse (ERIC) is sponsored by the National Center for Educational Communication, US Office of Education.

III. List of Exhibits accompanying report

Microfiches and copies of selected pertinent pages for:

1. Air Force Human Resources Lab: Low-Cost CA/CMI System Feasibility Study, 1979.
2. CB Training Starter Kit, Fed. Interagency for Computer Based Training. 1983
3. A Practical Approach to Computer Instruction Support. 1980
4. Guidelines for Optimum Utilization of Computer Training System as Based on an Analysis and Evaluation of Such Programs in the US Army. 1976

Catalogs

1. Conduit
2. ECS
3. Passport
4. TAP MMI
5. Wenger

Papers, copies of journal and literature articles in:

1. Cerl- A leader in CBI
2. Infoworld
3. Electronic Musician
4. Computers in Education
5. Computer Music Journal
6. Harvard Alumni Magazine
7. Reviews of sound synthesizers
8. Survey of Excellence in Education

Photos

Collection of over 100 slides of CAI software on screen of Apple IIe, IBM pc and Macintosh.

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13. Naisbitt, John, *Megatrends,* , 1982, pp. 17.

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21. Clark, D., Tuma, D., and Wilkins, C.J., "Computer Aided Sight-Reading," *Creative Computing*, No. 6, June 1980, pp. 84-89.

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